REPORT RESUMES

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CIVIL TECHNOLOGY, HIGHWAY AND STRUCTURAL OPTIONS, A SUGGESTED 2-YEAR POST HIGH SCHOOL CURRICULUM. TECHNICAL EDUCATION PROGRAM SERIES, NUMBER 8.

BY- BEAUMONT, JOHN A AND OTHERS
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DESIGNED TO ASSIST ADMINISTRATORS, SUPERVISORS, AND TEACHERS TO PLAN, DEVELOP, AND EVALUATE PROGRAMS, THIS CURRICULUM GUIDE OFFERS COURSE OUTLINES, PROCEDURES, LABORATORY LAYOUTS, TEXTS AND REFERENCES, LISTS OF LABORATORY EQUIPMENT AND ITS COST, AND A SELECTED LIST OF SCIENTIFIC AND TECHNICAL SOCIETIES. BASIC MATERIALS WERE PREPARED AT THE UNIVERSITY OF ILLINOIS PURSUANT TO A U.S. OFFICE OF EDUCATION (USOE) CONTRACT. THESE WERE REVISED, AND THE FINAL DRAFT WAS PREPARED BY USOE PERSONNEL. TECHNICAL COURSE OUTLINES FOR BOTH OPTIONS INCLUDE HOURS REQUIRED, DESCRIPTION INSTRUCTION SUGGESTIONS, MAJOR DIVISIONS, TEXTS AND REFERENCES, AND VISUAL AND TRAINING AIDS. SOME COURSES ARE--(1) TECHNICAL DRAWING, (2) CONSTRUCTION METHODS AND EQUIPMENT, (3) SURVEYING AND MEASUREMENTS, (4) SOILS AND FOUNDATIONS, AND (5) REINFORCED CONCRETE CONSTRUCTION. TEACHERS SHOULD HAVE ADVANCED TECHNICAL TRAINING. STUDENTS SHOULD BE HIGH SCHOOL GRADUATES WITH 1 1/2 YEARS OF ALGEBRA, 1 YEAR OF GEOMETRY, AND 1 YEAR OF PHYSICS. AN EXTENSIVE BIBLIOGRAPHY OF TEXTS AND REFERENCES IS GIVEN. THIS DOCUMENT IS ALSO AVAILABLE AS FS 5.280--80041 FROM THE SUPERINTENDENT OF DOCUMENT, U.S. GOVERNMENT PRINTING OFFICE, WASHINGTON, D.C. 20402, FOR $0.60. (EM)

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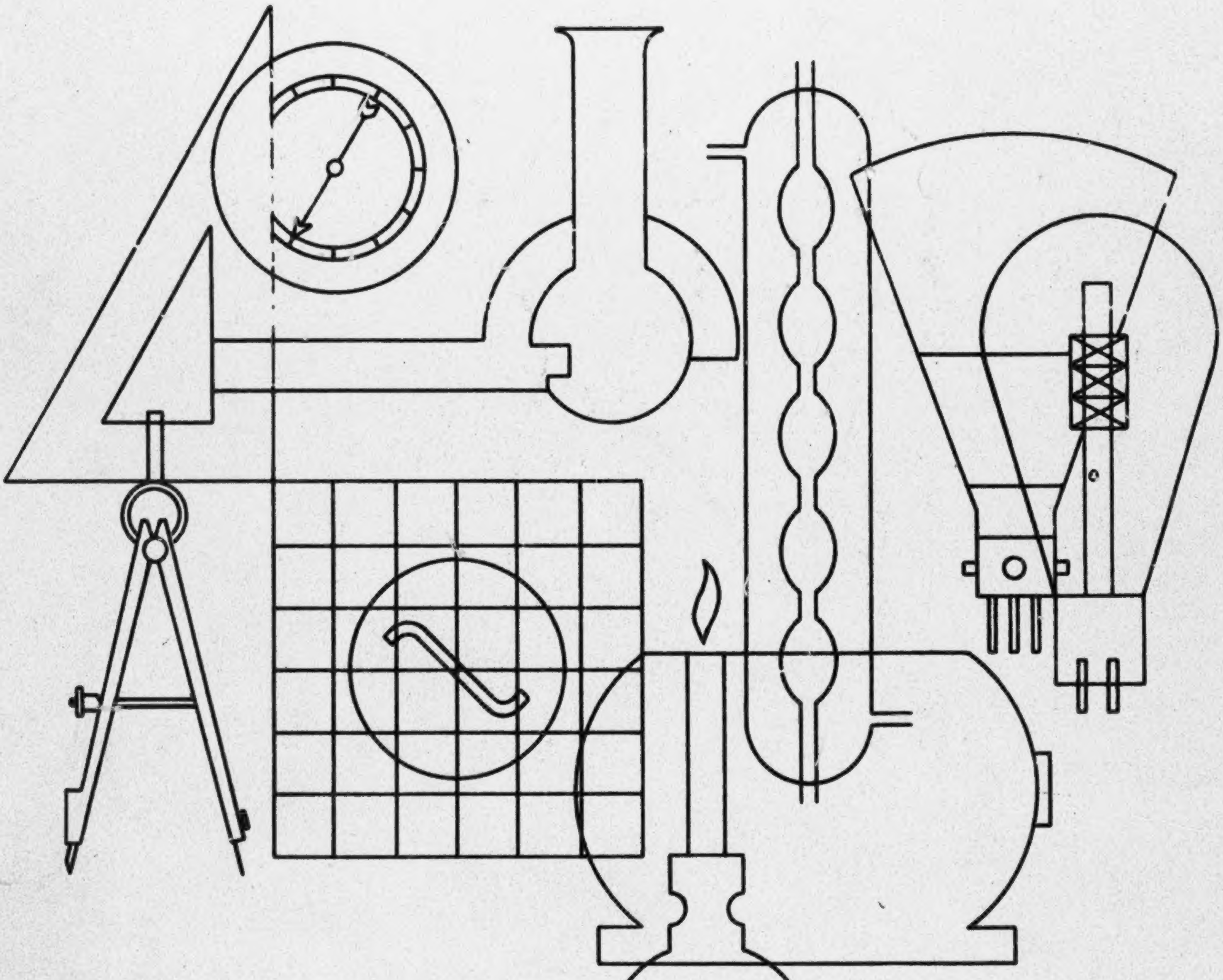
CIVIL TECHNOLOGY
HIGHWAY AND STRUCTURAL OPTIONS

A Suggested 2-Year Post High School Curriculum



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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
OFFICE OF EDUCATION

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U.S. Department of Health, Education, and Welfare------------------------------JOHN W. GARDNER, SECRETARY
Office of Education---HAROLD HOWE II, COMMISSIONER

FOREWORD

This suggested curriculum for a 2-year full-time program to educate highly skilled technicians has been developed to assist in meeting the need for highway and structural technology specialists. Persons who have mastered this preparatory curriculum will be equipped to serve as assistants to civil engineers and scientists in the broad field of highway and structural design and construction. Rapid technological development in the past 10 years and the major highway construction program have caused a shortage of skilled technicians in this area of applied science and technology.

The guide offers suggested course outlines, sequence of technical education procedure, laboratory layouts, texts and references, lists of laboratory equipment and its cost, and a selected list of scientific and technical societies. It is designed to assist school administrators, supervisors, and teachers who will be planning and developing new programs or evaluating existing programs in highway or structural technology. Although the indicated level of instruction is post high school, the sequence of course work may well start at any grade level where students have the prerequisite background and understanding.

This curriculum guide was developed by technical education specialists in the Occupations Section of the Division of Vocational and Technical Education, U.S. Office of Education. The basic materials were prepared by the University of Illinois, Department of General Engineering, pursuant to a contract with the Office of Education. (The final draft was prepared under the direction of John A. Beaumont, Director, Occupations Section, by Walter J. Brooking, assisted by Alexander C. Ducat, Robert M. Knoebel, and Robert L. McKee.)

Many useful suggestions were received from special consultants and from administrators and teachers in schools of technology. Although all suggestions could not be incorporated, each was considered carefully in the light of the publication's intended use. In view of this, it should not be inferred that the curriculum is completely endorsed by any one institution, agency, or person.

The technical accuracy of the curriculum materials is due largely to the work of a group of 10 outstanding engineers, industrialists, and educators who thoroughly reviewed these materials in conference with the technical specialists of the Occupations Branch.

WALTER M. ARNOLD
Assistant Commissioner for
Vocational and Technical Education

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Richard J. Beck, Assistant Professor, Civil Engineering Technology, Purdue University, Indianapolis Campus, 1125 East 38th Street, Indianapolis, Ind.

Thomas L. Bransford, Engineer of Materials, Research and Training, Florida State Road Department, Gainesville, Fla.

Jerry S. Dobrovolny, Head, Department of General Engineering and Project Director of Contract to prepare this guide, University of Illinois, Urbana, Ill.

Paul B. Hansen, Faculty Counselor, Milwaukee Institute of Technology, 1015 North Sixth Street, Milwaukee, Wis.

L. O. Herd, Chief, Aerial Engineer Section, Ohio Department of Highways, 65 South Front Street, Columbus, Ohio, 43215

C. T. Holladay, Head, Civil Engineering Technology Department, Southern Technical Institute, Marietta, Ga.

Robert E. McCord, Director, Continuing Education in Engineering (and Consultant to U.S. Office of Education), Pennsylvania State University, University Park, Pa.

R. Nady, Assistant Professor, Iowa State University of Science and Technology, Ames, Iowa

Alfred O. Quinn, Chief Engineer, Aero Service Corporation, 210 East Courtland Street, Philadelphia, Pa.

L. R. Schureman, Chief, Electronics Development Division, Bureau of Public Roads, U.S. Department of Commerce, Washington, D.C., 20235

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San Francisco, Calif.

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Astoria, Oreg.

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Buffalo, N.Y.

Ferris State College
Big Rapids, Mich.

Franklin Institute of Boston
Boston, Mass.

Hartford State Technical Institute
Hartford, Conn.

Lansing Public Schools
Division of Engineering Technologies
Lansing, Mich.

Madison Vocational Technical and Adult Schools
Madison, Wis.

North Dakota State School of Science
Wahpeton, N. Dak.

Northeastern Junior College
Sterling, Colo.

Oklahoma State University
The Technical Institute
Stillwater, Okla.

Pearl River Junior College
Poplarville, Miss.

Salem Technical Vocational School
Salem, Oreg.

Texas A. & M. University
College Station, Tex.

Utah State University
Logan, Utah

Wentworth Institute
Boston, Mass.

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CIVIL TECHNOLOGY PROGRAM

Scientific research and new technological developments have made great changes in the field of civil engineering in the past decade. These changes have been particularly evident in the engineering and construction of highway systems and in the design and building of major structures.

In surveying for roadway route-selection and design, civil engineers and technicians increasingly make use of photogrammetry, using automatic plotting machines to scribe routes from aerial photographs of rural or urban areas. Route data obtained by photogrammetry may then be processed through electronic data processing computers to calculate land acquisition, grading, and construction costs for alternate routes with greater accuracy and far greater speed than by former methods. New electronic distance-measuring devices provide surveyors with more accurate measurements of distance, made much more quickly and economically, than were possible with tapes or rod and chain.

Civil engineers and technicians who design and build bridges, causeways, structural frames for buildings, airports, water control systems, and rocket launching or testing installations use newly developed materials, methods, concepts, and techniques making feasible many structural designs and projects that were hitherto uneconomical or impossible. By using electronic data processing computers, designers of structures may now make the total computation of not one but several alternative designs for a structure in a few hours—a task that was physically impossible only a few years ago.

Figure 1.—The surveyor's careful measurements provide the controlling location and elevation points from start to finish in highway construction. Highway technicians can do much of the checking and control survey work during the progress of construction.

The critical-path method of planning and programing a construction project affords a basis for evaluating and scheduling large and complicated construction jobs so that the sequence of operations continually concentrates on the element or task which will take the most time at any given point in the program. This makes possible the most efficient and economical use of men and machines to complete the total job.

Such important and even revolutionary developments in the field of civil engineering applied to highway construction and the building of structures have increased the need for improved technical education for both engineers and their delegates and assistants—the highly skilled technicians.

GENERAL CONSIDERATIONS

The increasing demands upon personnel in technical occupations are such that additional organized education beyond the high school is a prerequisite for success in these occupations. To avoid job obsolescence brought about by advances in technology, broad technical training must be obtained. The abilities required by technical personnel have been summarized as follows:[1]

1. Facility with mathematics; ability to use algebra and trigonometry as tools in the development of ideas that make use of scientific and engineering principles; and understanding of, though not necessarily facility with, higher mathematics through analytical geometry, calculus, and differential equations, according to the requirements of the technology.
2. Proficiency in the application of physical science principles, including the basic concepts and laws of physics and chemistry that are pertinent to the individual's field of technology.
3. An understanding of the materials and processes commonly used in the technology.
4. An extensive knowledge of a field of specialization with an understanding of the engineering and scientific activities that distinguish the technology of the field. The degree of competency and the depth of understanding should be sufficient to enable the individual to do such work as detail design using established design procedures.
5. Communication skills that include the ability to interpret, analyze, and transmit facts and ideas graphically, orally, and in writing.

Similar criteria have been identified in a subsequent study by the American Society for Engineering Education.[2] Both of these reports stress the need for a carefully structured program of instruction based upon a solid core of mathematics and science, and their recommendations have been largely incorporated in this suggested guide.

The emphasis in this curriculum is on the fundamental sciences basic to civil engineering and the application of these sciences in the technology—the functional work of the engineering team whose efforts are exhibited in highways, bridges, airports, waterways, and structures of many kinds. Courses in design and analysis are included for this purpose. Laboratory work is provided in materials, processes, and the specialized skills in civil engineering work.

The object of the program is to provide as comprehensive and well-balanced instruction in applied civil engineering and related science as is practicable in an intensive 2-year schedule. Two options are offered, from which a student may choose an area of specialization—highway design and construction, and structural design and construction. The program leads to employment as surveyor, draftsman, junior designer, assistant to construction supervisors, materials and soil tester, and expediter or liaison specialist between contractors and civil engineers in charge of construction projects.

Upon successful completion of either option of this course of study, the technician will be able to perform most of the following duties, among others: Developing preliminary sketches; preparing working and detailed drawings; making the more routine calculations; functioning as a surveyor's assistant; helping to prepare estimates; assisting the resident engineer; performing the more elementary detail designing of roadways or structures under the supervision of an engineer; executing routine material tests, including sample taking, data plotting, and acting as a field recorder and inspector, and handling various other technical tasks assigned to him by an engineer.

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[1] U.S. Department of Health, Education, and Welfare, Office of Education, *Occupational Criteria and Preparatory Curriculum Patterns in Technical Education Programs* (OE–80015), Washington: U.S. Government Printing Office, 1962, p. 5.

[2] American Society for Engineering Education, *Characteristics of Excellence in Engineering Technology Education*, Washington, 1962.

The intent is not to make the individual proficient in all of the duties he might be asked to undertake; proficiency in work of a highly specialized nature will come with practice and experience. Furthermore, it is expected that the graduate technician will continue to study throughout his career in order to develop to his fullest capabilities. The curriculum does aim, however, at enabling the technician to use judgment and make decisions in the course of his work.

A 2-year curriculum must concentrate on primary needs if it is to prepare individuals for responsible technical positions in modern industry.[3] The program must be thoroughly pragmatic in its approach and must involve a high order of specialization. The curriculum suggested here has been designed to provide maximum technical instruction in the time that is scheduled. To those not familiar with this type of educational service (or with the goals and interests of students who elect it), the technical program may appear to be inordinately rigid and restrictive. Modifications may be necessary in certain individual institutions, but the basic structure and content should be maintained.

A technical curriculum usually has four subject-matter divisions: (1) Specialized technical courses in the technology, (2) auxiliary or supporting technical courses, (3) mathematics and science courses, and (4) general education courses. The technical subjects deal with application of scientific and engineering principles. For this reason, mathematics and science courses must be coordinated carefully with technical courses at all stages of the program. This coordination is accomplished by scheduling mathematics, science, and technical courses concurrently during the first two terms—a curriculum principle that will be illustrated at several points. General education courses constitute a relatively small part of the total curriculum. It has been found that students who enter a technical program do so because of the depth of specialization that the instruction provides. Many students who elect this training program will bring to it a background of general study.

Faculty

The ultimate effectiveness of the curriculum depends largely upon the quality of the faculty. The specialized nature of the instruction requires that the teachers have special competencies based on proficiency in technical subject matter and industrial experience. It is important also that all members of the technical education faculty understand the educational philosophy, goals, and unique requirements that characterize this type of educational program. Furthermore, the staff must be able to work together as a unit, since the subject matter cannot be taught as a series of independent courses. It must be presented as a closely integrated combination and sequence of educational experiences.

Teachers of specialized technical subjects require advanced technical training. In the past, many of these trainees have been recruited from the ranks of the engineering profession. Recent experience has shown that engineering technology graduates who have acquired suitable industrial experience and who have continued their technical education often become excellent teachers in this field. With their background, they understand the objectives and unique instructional requirements of technical education and are apt to have enthusiasm as well as skill.

Faculty members should be encouraged to participate as active members in professional and technical societies associated with their technical speciality as a means of updating their technical knowledge and skills and fostering acquaintance with persons in the community who are most actively interested in the field. (Increasingly administrators are paying part or all of the cost of membership and attendance of local or national meetings of selected societies as an incentive to faculty participation.) The staff should also be encouraged to keep up with the professional education literature in their field, to continue their education, and to maintain close liaison with industry in the area of their specialities. This encouragement may be provided in the form of released time and financial assistance to attend special teacher training institutes, such as those conducted by the National Science Foundation and various colleges and universities in cooperation with State boards for vocational education.

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[3] U.S. Department of Health, Education, and Welfare, Office of Education, *Occupational Criteria and Preparatory Curriculum Patterns in Technical Education Programs* (OE–80015), Washington: U.S. Government Printing Office, 1962, pp. 10–17.

When teaching loads for faculty members conducting specialized technical courses are being determined, consideration should be given to the number of contact hours rather than to the normal assignments for shop teachers or to the number of course-credit hours. In addition to usual teaching responsibilities, such teachers need to devote a large amount of time to preparation for laboratory sessions, development of special instructional aids, assisting students with individual projects, and reviewing reports. An effective teaching load probably would be 15 to 20 contact hours.

Student Selection and Services

While the effectiveness of a technical education program depends greatly upon the quality of the faculty, it depends even more on the quality of the students. It is essential, therefore, that persons accepted for instruction have certain capabilities and exhibit some evidence of maturity and seriousness of purpose. If the incoming students' backgrounds are inadequate, instructors will tend to compromise the standards of course work. The probable result will be a program limited in depth and scope, inefficient use of faculty and facilities, and poorly prepared graduates who are not attractive to employers.

This curriculum is intended for high school graduates who have particular abilities and interests. In general, students entering the program should have completed 1½ years of algebra, 1 year of geometry, and 1 year of physical science, preferably physics. It should be recognized that the ability levels of those who do or do not meet these general requirements will vary greatly and that some students may have to take refresher courses in mathematics or English to make satisfactory progress.

Effective guidance and counseling is essential. The student should be aided in selecting educational and occupational objectives consistent with his interests and aptitudes. Whenever possible, institutions offering technical education programs should consider the use of standardized or special tests to assist in student selection, placement, and guidance. A student should be advised to revise his educational objectives if it becomes apparent, by reason of either lack of interest or lack of ability to make satisfactory progress, that he is more suited to other programs.

Students of civil technology should be made aware of the literature and services of scientific, technical, and engineering societies early in their study program. Student affiliate memberships are offered by some of these societies, and students should be encouraged to become such members.

Graduates should be given all possible assistance in finding suitable employment, for the benefit of the students, the institution, and industry. Placement personnel should be aware of the needs of industry and should acquaint prospective employers with the qualifications of graduates. The school also has a continuing responsibility for the followup of employed graduates, whose success is a measure of the effectiveness of the program. In addition, graduates can provide a helpful advisory service.

Textbooks, References, and Visual Aids

Textbooks, references, and visual aids for teaching any technology must constantly be reviewed and supplemented in light of (1) rapid development of new knowledge in the field and (2) results of research in methods of teaching and developing basic concepts in the physical sciences and mathematics. The constant expansion of theoretical and applied scientific knowledge causes the production of new textbooks and references, new material in scientific and technical journals, and new visual aid and demonstration materials. Extensive research in methods of teaching science is altering teaching materials and methods as fast as it becomes applicable. It is therefore mandatory that instructors constantly review new texts, references, and visual aid materials and adopt them when they supersede those recommended here or those being used in present programs.

The suggested texts have been carefully selected for suitability. It should not be assumed, however, that unlisted books are not suitable; there are, no doubt, many other excellent sources which could be included.

Before a department head or instructor undertakes a program in civil technology or any course

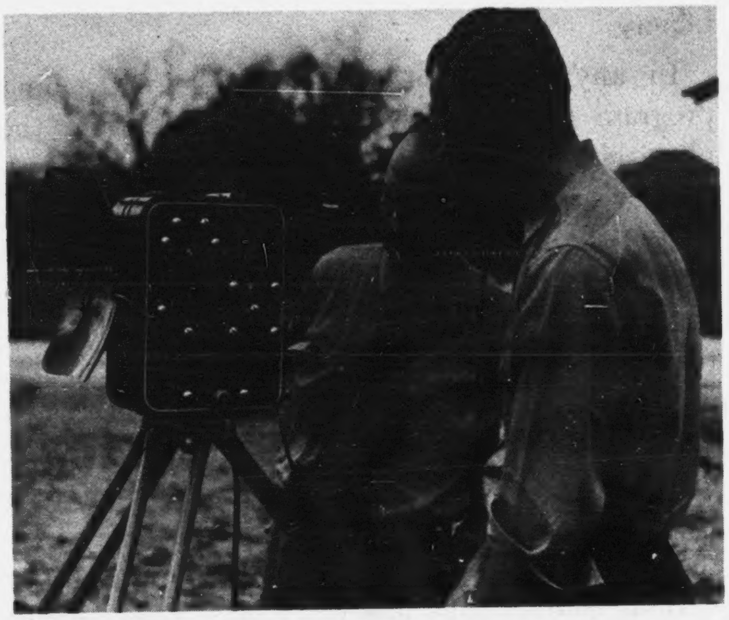

Figure 2.—Technological developments have introduced new instruments, such as this tellurometer for accurately and quickly measuring distances. Modern highway technicians should be proficient in the use of such new instruments.

contained in the curriculum, he should familiarize himself with the texts and references listed here and with all new ones available. He will then be able to select the text which best serves his particular needs in providing a lucid, high-level technical presentation to his students.

Visual aids can be of great help in many teaching programs. Those cited here were selected from a very extensive list and were considered suitable at the time the curriculum was prepared. Many were not mentioned because the variety and extent of the materials made an all-inclusive study prohibitive. From those listed and from others available and pertinent, an instructor may select the visual aids which meet his teaching objectives.

Scientific and technical societies are an important source of instructional materials.[4] Such societies provide in their publications and in their regularly programed meetings a continuing disclosure and discussion of new concepts, processes, techniques, and equipment in the sciences and related technologies. They are probably the greatest single medium through which persons engaged in applying a particular body of scientific knowledge keep abreast of new developments. Their data are presented in such a popular and informative manner as to provide a bridge between the creative theoretical scientist and the applied sciences practitioners, including the technicians.

The American Society of Civil Engineers, 345 East 47th Street, New York, N.Y., is one of the most important societies whose publications serve the specific interests of civil technicians and the faculties who teach them. The content of their *Journal* is addressed to their 45,000 members and also contains materials specially slanted to the 14 student chapters which are associated with local chapters of the society. Examples of other societies which may be of special interest to students and instructors of civil technology are:

American Association of State Highway Officials
American Concrete Institute
American Congress on Surveying and Mapping
American Institute of Architects
American Iron and Steel Institute
American Railway Bridge and Building Association
American Railway Engineering Association
American Sanitary Engineering Intersociety Board
American Society for Engineering Education
American Society for Testing Materials
American Society of Civil Engineers
American Society of Heating, Refrigerating, and Air-Conditioning Engineers
American Society of Photogrammetry
American Society of Safety Engineers
American Society of Sanitary Engineering
American Water Works Association
American Welding Society
Association of Asphalt Paving Technologists
Association of Iron and Steel Engineers
Engineers' Council for Professional Development
Engineers Joint Council
Highway Research Board
Institute of Traffic Engineers
National Society of Professional Engineers
Society of American Military Engineers
United States National Committee, International Commission on Irrigation and Drainage

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[4] U.S. Department of Health, Education, and Welfare, Office of Education, *Scientific and Technical Societies Pertinent to the Education of Technicians* (OE–80037), Washington: U.S. Government Printing Office, 1965.

A brief description of each of these societies is given in appendix A.

Equipment and Facilities

Laboratories and equipment for teaching a civil technology program must meet high standards of quality since the strength of the curriculum lies in providing valid laboratory experience, basic in nature, broad in variety, and intensive in practice. Well-equipped laboratories with sufficient facilities for all students to do actual laboratory work are required for these courses. In training for civil engineering and related construction work, competency is needed in the knowledge and skills of engineering drawing, the use of surveying and related instruments, soil and materials, laboratory testing equipment, precision measuring and computing devices, and scientific and engineering handbooks, as well as some knowledge of construction equipment, methods, costs, and legal regulations.

Variety and quality of laboratory equipment and facilities are more important than quantity. Such equipment and facilities are a major element of the cost of the program, but they are indispensable if the training objectives are to be met. This is discussed more specifically under "Facilities, Equipment, and Costs."

Library

In any evaluation of a technology teaching program the qualifications of the librarian, the physical facilities, the quality, quantity, and pertinency of content, and the staffing and organization of the library give tangible indications of the strength of the program.

Dynamic developments causing rapid changes in technological science and practice make it imperative that the student of any technology learn to use a library. Therefore, instruction for students in technologies should be library-oriented so that they learn the importance of knowing where they can find information relative to any of the various courses they are studying. They should learn the use of a library and form the habit of using it as a tool in the learning process. This helps to develop the professional attitude in the student, and further assists him to depend on libraries as a means of keeping abreast of the new developments in a rapidly changing technology when he graduates and is employed.

Instructors of all courses should constantly keep the student aware of the extent to which a library contains useful information which can be helpful and is a part of the study in his curriculum. Planned assignments of library projects calling for the student to go to the library and prepare re-

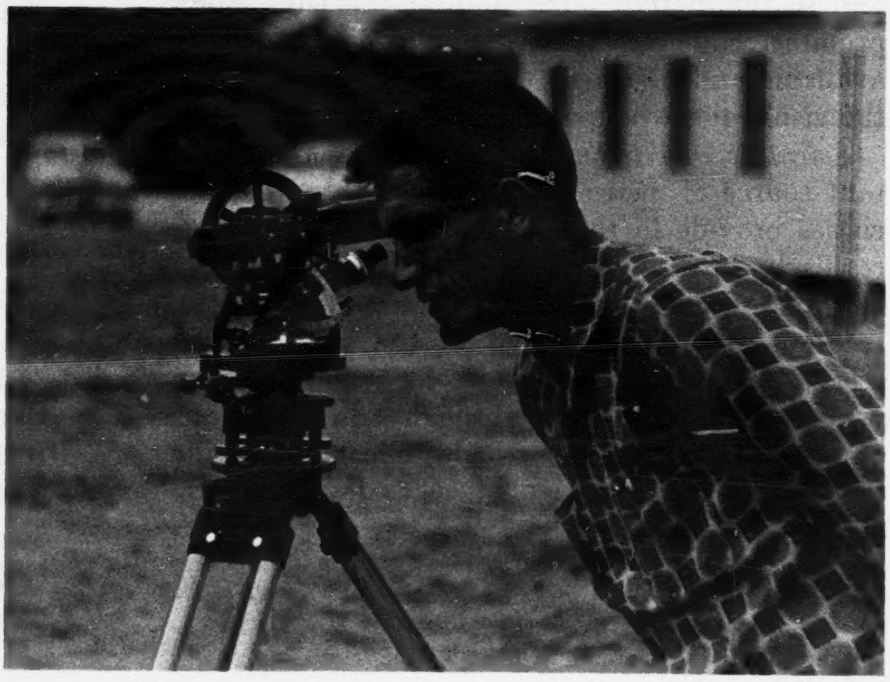


***Figure 3.*—The Solar Transit is an instrument for precise determination of fixed points in surveying. Its use and application should be understood by technicians whose work requires a comprehensive understanding of surveying.**

ports on pertinent subjects in his courses enable him to understand the resources available in libraries and how they relate to his technology. Open-book examinations requiring the use of the library provide excellent and objective experiences for the student. Under the incentive of the examination and the press of time, the understanding of his own competency in library skills becomes clear to each student.

The growth and success of the graduate technician will depend in large measure on his ability to keep abreast of changes in his field. Libraries are information source agencies with trained personnel who classify source data and assist those seeking it to find pertinent information quickly.

For these reasons a central library under the direction of a professional librarian is important to the success of the teaching of technology curriculums. Most instructors have private libraries in their offices from which they may select books of special interest in their personal conferences with students and thereby stimulate interest in related literature. However, a central library, under the direction of a professional librarian, insures the acquisition and cataloging of the library content according to an accepted library practice, and provides the mechanics for location of reference materials by the use of systematic card files. It also provides the mechanics for lending books to students in a controlled and orderly manner typical of libraries which they might encounter in the course of solving problems in employment after leaving school.

Study space with suitable lighting and freedom from outside distractions should be provided in the library for short-term study of reference data; and provisions for the checking out of reference materials for out-of-library use should be systematic and efficient.

The content of a library must adequately provide the literature containing the knowledge encompassed by all subjects in a curriculum and extending somewhat beyond the degree of complexity or depth encountered in classroom activities. Literature dealing with unusually high specialized aspects of a subject may be acquired as needed or may be borrowed by the librarian from more comprehensive libraries.

The teaching staff and the library staff should actively cooperate with one another. The teaching staff must cooperate with the library staff on materials to be acquired and should be responsible for the final selection of the materials that support their technical courses. They must take the initiative in recommending new library content to keep it current, pertinent, and useful. The library staff should supply the teaching staff periodically with a list of recent acquisitions, complete with call numbers. Technical journals should either be circulated to the teaching staff or placed in a staff reserve area for a short time before they are made available for general library use.

In addition to reference materials, journals, and trade publications, a library should have available material of an encyclopedic nature for quick reference index (such as the *Engineering Index*) to aid staff and students in finding recent material on specific subjects.

Visual aids may be handled by the library. They should be reviewed and evaluated by both the librarian and a member of the teaching staff as they become available. This procedure will insure that appropriate visual aids are acquired by the library and should familiarize members of the teaching staff with exactly what is available and where these aids may be best used in the technical programs.

A well-equipped, modern library should have some type of duplicating service so that copies of library materials may be easily obtained by students and staff. This service allows both students and staff to build up-to-date files of current articles appropriate to the courses in a curriculum. This service should be available to the students at minimum cost and free of personal cost to the staff. A satisfactory arrangement, based on experience, utilizes a large dry-copy machine and allows the duplication of library materials for students at the rate of 5 cents per page. The teaching staff is allowed duplication of up to 20 pages per day without personal charge to the instructor; any excess is charged either to the department having material duplicated or to the staff member at the rate of 5 cents per page.

THE CURRICULUM

Civil Technology—Highway Option

	Hours per week for 16-week semester				
Course title	*Class*	*Laboratory*	*Outside study*	*Total*	*Credit-hours*
First Semester					
Materials (Chemistry and Properties)	2	3	4	9	3
Technical Drawing	1	7	4	12	4
Technical Mathematics I	5	0	10	15	5
Technical Physics I (Mechanics)	3	2	4	9	3
Communication Skills	3	0	6	9	3
Highway and Structural Technology Seminar	1	0	2	3	0
	15	12	30	57	18
Second Semester					
Construction Methods and Equipment	3	0	6	9	3
Mechanics (Statics and Dynamics)	3	0	6	9	3
Surveying and Measurements	2	6	4	12	4
Technical Mathematics II	5	0	10	15	5
Technical Physics II	3	2	4	9	3
	16	8	30	54	18
Third Semester					
Advanced Drafting (Highway)	1	7	4	12	4
Industrial Organizations and Institutions [1]	3	0	6	9	3
Soils and Foundations	2	3	4	9	3
Strength of Materials	3	2	6	11	4
Technical Reporting	2	0	4	6	2
Photogrammetry	1	3	2	6	2
	12	15	26	53	18
Fourth Semester					
Drainage and Geology	3	3	6	12	4
Reinforced Concrete Construction	3	2	6	11	4
Roadway Design and Construction	3	4	8	15	5
Route Design and Surveys	2	4	4	10	3
Legal and Economic Aspects of Engineering	2	0	4	6	2
	13	13	28	54	18

[1] General and Industrial Economics (3-hour class) may be chosen as an elective instead of Industrial Organizations and Institutions.

Brief Description of Courses

First Semester (Highway and Structural Options)

Materials (Chemistry and Properties)

Introductory study of the nature, origin, properties, and use of construction materials. The elementary chemical nature of materials and their interactions is considered. Field and laboratory tests for identification, classification, and control are studied in both class and laboratory work.

Technical Drawing

Integrated course in engineering drawing and geometric problem-solving for students with little or no knowledge of mechanical drawing. Drawing, dimensioning, and solving of functional problems involving engineering geometry are emphasized.

Technical Mathematics I

Study of algebra, trigonometry, and numerical computations beginning with learning to use a slide rule. The course is closely integrated with the topics studied in physics and technical drawing.

Technical Physics I (Mechanics)

Course designed to develop an understanding of the basic principles of mechanics applied to solid particles and fluids. The content is coordinated with Technical Mathematics I.

THE CURRICULUM—Continued

Civil Technology—Structural Option

Course title	Hours per week for 16-week semester				
	Class	Laboratory	Outside study	Total	Credit-hours
First Semester					
Materials (Chemistry and Properties)	2	3	4	9	3
Technical Drawing	1	7	4	12	4
Technical Mathematics I	5	0	10	15	5
Technical Physics I (Mechanics)	3	2	4	9	3
Communication Skills	3	0	6	9	3
Highway and Structural Technology Seminar	1	0	2	3	0
	15	12	30	57	18
Second Semester					
Construction Methods and Equipment	3	0	6	9	3
Mechanics (Statics and Dynamics)	3	0	6	9	3
Surveying and Measurements	2	6	4	12	4
Technical Mathematics II	5	0	10	15	5
Technical Physics II	3	2	4	9	3
	16	8	30	54	18
Third Semester					
Advanced Drafting (Structural)	2	8	5	15	5
Industrial Organizations and Institutions [1]	3	0	6	9	3
Soils and Foundations	2	3	4	9	3
Strength of Materials	3	2	6	11	4
Technical Reporting	2	0	4	6	2
	12	13	25	50	17
Fourth Semester					
Applied Building Construction	3	3	6	12	4
Estimating and Office Practices	3	4	5	12	4
Reinforced Concrete Construction	3	2	6	11	4
Structural Detailing and Design	3	3	6	12	4
Legal and Economic Aspects of Engineering	2	0	4	6	2
	14	12	27	53	18

[1] General and Industrial Economics (3-hour class) may be chosen as an elective instead of Industrial Organizations and Institutions.

COMMUNICATION SKILLS

A program designed to promote greater competence in reading, writing, talking, and listening.

HIGHWAY AND STRUCTURAL TECHNOLOGY SEMINAR

Noncredit course designed to acquaint the student with the school, the programs of study, the nature of the work performed by technicians, and the opportunities available to them.

Second Semester (Highway and Structural Options)

CONSTRUCTION METHODS AND EQUIPMENT

Study of available equipment and its use in excavation, materials production, and building highways or erecting structures. Planning and analysis of operating costs and efficiencies are emphasized.

MECHANICS (Statics and Dynamics)

Introduction to the basic concepts of mechanics, emphasizing the action of forces on rigid bodies. The course starts with forces acting on stationary bodies (statics), followed by a study of forces acting on bodies in motion (dynamics).

SURVEYING AND MEASUREMENTS

Beginning course designed for students with little or no training in surveying. It combines lectures, laboratory, and field work in theory, methods, equipment, and problems involved in surveying and measurement and their application.

TECHNICAL MATHEMATICS II
Study of mathematics, especially trigonometry, vectors, solid geometry, and an introduction to calculus and its application to problems of highway construction or the building of structures.

TECHNICAL PHYSICS II
Course designed to develop an understanding of the basic principles of heat, sound, light, electricity, and magnetism as they relate to civil technology. The content is closely coordinated with Technical Mathematics II.

Third Semester (Both Highway and Structural Options Unless Otherwise Noted)

ADVANCED DRAFTING (Highway Option)
Course designed to provide the student with training and experience in drafting-room procedures and practice. It includes topographic map drawing, structural steel, and reinforced concrete drawing.

ADVANCED DRAFTING (Structural Option)
Course designed to provide the student with training and experience in drafting-room procedures and practice. It includes architectural drawing, structural steel, and reinforced concrete structure drawing.

INDUSTRIAL ORGANIZATIONS AND INSTITUTIONS
Study of roles played by labor and management in the development of American industry. Analysis is made of forces affecting labor supply, employment, and industrial relations under the democratic system of government.

GENERAL AND INDUSTRIAL ECONOMICS
Study of general economics principles, and analysis of the factors involved and importance of cost control in an industrial enterprise.

SOILS AND FOUNDATIONS
Elementary study of exploring, sampling, testing, and evaluating subsurface materials, and their effect on types of foundations and construction.

STRENGTH OF MATERIALS
Introductory study of strength of materials in relation to loads on structural units, joints, beams, columns, and total structures.

TECHNICAL REPORTING
Study of effective ways of presenting information. The student learns the utility of graphs, drawings, sketches, and outlines for various types of oral and written reports.

PHOTOGRAMMETRY (Highway Option)
Elementary course to develop an understanding of the principles, equipment, techniques, and applications of photogrammetry in highway engineering and construction. This course is strongly laboratory-oriented.

Fourth Semester (Both Highway and Structural Options Unless Otherwise Noted)

DRAINAGE AND GEOLOGY (Highway Option)
Introductory study of basic fluid mechanics. Includes geology of streams, watersheds, and drainage and their influence on concepts of design of drainage systems, culverts, and bridges.

APPLIED BUILDING CONSTRUCTION (Structural Option)
Course planned to acquaint the student with terminology, methods, procedures, materials, sequences of operations, types of construction, and planning involved in construction of buildings.

ESTIMATING AND OFFICE PRACTICES (Structural Option)
Introduction to the functions and operations of a construction office, including planning, scheduling, estimating, purchasing, cost accounting, and control, with a brief consideration of the use of electronic data processing and computer applications to such operations.

REINFORCED CONCRETE CONSTRUCTION
Study of the properties of reinforced concrete and its capability to carry stresses in designs involving columns, beams, and slabs. Construction procedures and cost-estimating are considered.

ROADWAY DESIGN AND CONSTRUCTION (Highway Option)
Study of roadway foundations, pavement surface properties, composition and design of flexible and of concrete pavements, pavement and subgrade construction, and a brief consideration of railroad tracks and trackbeds. The work in this course is closely coordinated with the concurrently studied course on route design and surveys.

ROUTE DESIGN AND SURVEYS (Highway Option)
Study of highway route design, including factors affecting route location; design of simple, spiral, and vertical curves; grades and related earthwork; and a consideration of modern surveying, measuring, and mapping instruments.

STRUCTURAL DETAILING AND DESIGN (Structural Option)

Introduction to structural analysis and design of simple static steel structures, and a brief study of timber structure design. Drafting-room detailing practice and the origin, development, and importance of details are emphasized.

LEGAL AND ECONOMIC ASPECTS OF ENGINEERING

Introductory study of the law as it applies to construction and engineering contracts and property, and an introductory consideration of cost-estimating and financial evaluation for engineering purposes.

Curriculum Content and Relationships

Achievement of functional competence in a broad field such as civil technology makes three major demands upon preparatory technical training: (1) The training should equip the graduate to take an entry job in which he will be productive; (2) it should enable him to advance to positions of increasing responsibility after a reasonable amount of experience; and (3) it should provide a foundation broad enough to support further study within the graduate's field of technology. This curriculum has been designed to meet these three requirements.

A 2-year technology program has certain unique characteristics that influence the content and organization of the curriculum. Some of these are imposed by the occupational functions that graduates must be prepared to perform; some result from the need for special courses that will maximize the effectiveness of teachers who have special competencies; and others arise because of the need to teach both technical principles and related practical applications in the limited time available. This civil technology curriculum accordingly emphasizes functional utility, units of instruction in specialized technical subjects, and provision for the teaching of principles by application.

Highway Construction and Structural Options

The courses in this curriculum provide students with a choice of specialization within the general field of civil engineering work after the first year of study, which is common to both.

The highway option is directed toward building highways, airfields, water control and distribution systems, and similar projects. Since these construction programs usually involve extensive earthmoving, grading and foundation preparation, and surfacing over sizable distances or areas, the courses are planned to develop competencies in surveying and mapping, drainage, soil mechanics, design of highway contours, and related details; understanding of materials and processes of surfacing and finishing; and knowledge of the economic and legal aspects of such operations.

The structural option emphasizes the building of bridges, dams, water storage tanks, and the structures and mechanisms associated with water control or purification, permanent launch and test facilities for rockets, and others. This option, therefore, provides specialization in the skills and knowledge required to design and build the major structures within a system.

The first two semesters of the highway option are identical to the first two semesters of the structural option. It is expected that students will choose either the highway or the structural option, on the basis of their interests and abilities, at the beginning of the third semester. In the third and fourth semesters of each option the problem-solving approach is used, especially in the fourth term, to give as broad a perspective as possible and to make full use of previous course work.

The sequence of courses in a 2-year technical curriculum is as important as the content. In general, the subject matter is carefully correlated in groups of concurrent courses. This is in sharp contrast to the arrangement of professional curriculums in which basic and somewhat unrelated courses make up the first part of the study program and specialization is deferred to subsequent terms.

In technical curriculums it is mandatory that specialized technical course work be introduced in the first term. Deferring this introduction for even one term imposes serious limitations on the effectiveness of the total curriculum. Several important advantages accrue from the early introduction of drafting and a study of materials to begin the technical specialty: (1) Student interest is caught by practical aspects (because if the first term consists entirely of general subjects—mathematics, English, social studies—students often lose interest); (2) by introducing technical study in the first term it is possible to obtain greater depth of understanding in specialized subjects in the later stages of the 2-year program; and (3) practice is gained in the application of mathematics in the technical courses.

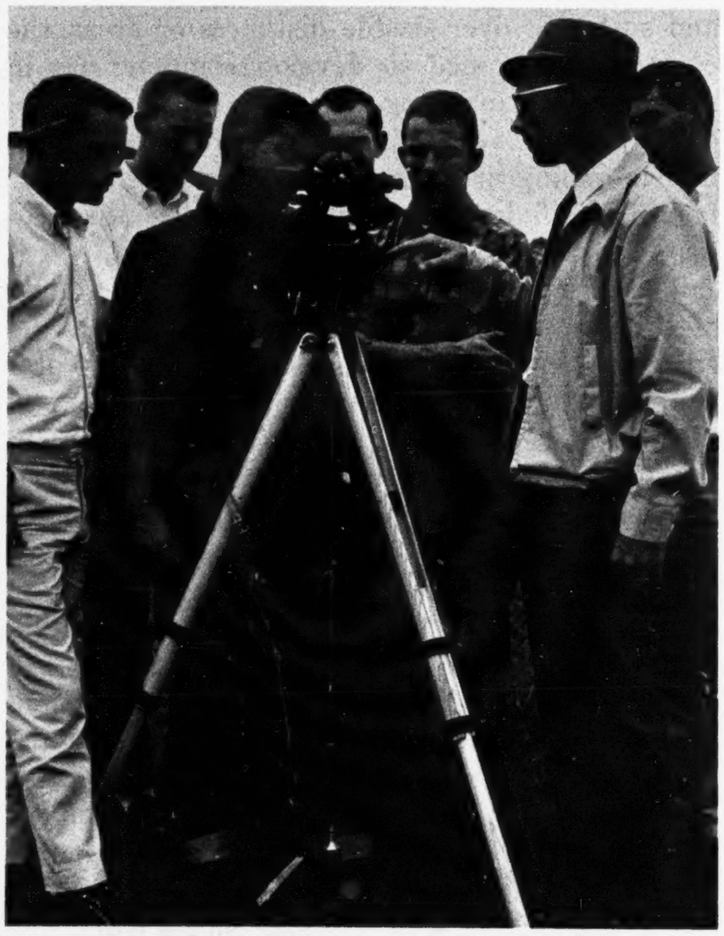


Figure 4.—**Technicians studying either the highway or structural option in civil technology must master the operation and use of the transit. This is accomplished by classroom study of the principles and function of the instrument, and by extensive field practice in its use.**

The student's study in mathematics is reinforced by his application of the disciplinary values obtained therefrom and the need for these values in technical study.

Safety and care must be taught as underlying requisites of all construction work. Such operations often involve potential dangers that careful procedures, combined with understanding of the materials, equipment, and safe working practices, can avoid. Safety is a constant preoccupation of all construction and allied industries and observance of its rules must be taught continually from the beginning of the program.

Communication is an important element of technical work. The educational program should include specific instruction in graphic, written, and oral communication. In addition to these specifics, there should be a continual emphasis on written reports with rising standards of attainment as the student progresses in the program. Elements of industrial sociology, psychology, and economics, while necessarily limited by the time factor, should be considered important units of the curriculum.

The course outlines in this guide are short and descriptive. The individual instructor will have to prepare complete courses of study and arrange the curriculum material in logical order of teaching before starting instruction. Suggested laboratory layouts and equipment found in the section on facilities, equipment, and costs may be helpful to instructors in preparing to teach the courses.

The instructional material is not intended to be applied to a given situation exactly as outlined; it is presented to illustrate the form and content of a complete civil technology program in the two options presented. In keeping with the form of previously published guides, it is planned as a full-time post high school preparatory program, but is expected to be of use also in planning extension courses and preparatory or pretechnical programs in secondary schools.

The course on materials used in highway construction is given in the first term to let the students gain a fundamental understanding of the materials to be used in their field of specialization. The content of the courses in physics and mathematics is presented in light of applications to civil engineering work, and the course in technical drawing lays the groundwork for specialization in drawing and design in subsequent terms.

Courses in surveying and measurement and in construction methods and equipment provide further fundamental knowledge and skills in the civil technology specialty in the second semester. The surveying course applies the mathematics taught in the previous semester and that being taught concurrently with surveying, as Mathematics II. The Technical Physics II and Mechanics courses provide further study in depth of the physical sciences related to the field of specialization.

The course in photogrammetry is included because most State highway departments and many related engineering and contracting firms have adopted photogrammetric methods. These involve aerial photographs, stereoplotters, and other specialized equipment and techniques used in surveying, mapping, route planning, estimating, and design. The highway technician must be introduced to photogrammetry and its application so that he may understand this important and growing development.

Study of soils and foundations, strength of materials, and advanced drafting (either in highway option or structural option) extends the student's technological specialty and builds upon the science and mathematics courses studied in the preceding terms.

Fourth and final term courses in each option are designed to consolidate further the student's understanding of the application of the mathematics and science to his particular field. In both the highway and structural options the design courses and the specialized construction courses provide each student with opportunity to do more and more individual work, making use of previously learned concepts. Students are encouraged to do independent work in which decision making is involved because the ability to do such work is one of the important criteria for advancement in technical occupations.

The two courses in mathematics are designed to meet the specific needs of the student in this program and include selected topics in algebra, trigonometry, analytical geometry, and calculus. The inclusion of calculus in the Technical Mathematics portion of the program is not intended to make the student proficient in all aspects of calculus, but rather to give him the ability to understand concepts which will allow him to communicate with engineers. The student's background in calculus should be broad enough to allow him to follow, though not necessarily reproduce, the development of equations which require the use of calculus. This would include the differentiation of elementary functions for determination of instantaneous velocities and accelerations which occur in the study of dynamics and technical physics. The integration of elementary functions is equally important in the development of the theory of the moment-area method for finding the deflection of beams as used in strength of materials. Other examples of problems which can be treated in a more satisfactory manner with the use of the elementary concepts of calculus will occur throughout the program.

The social science courses are designed to broaden the student's concepts and perception of the society in which he lives and will be employed. These courses include broad economic and industrial concepts and sufficient emphasis on corporate structure and economics to enable the student to comprehend the terminology and recognize the motives, methods, objectives, and administrative procedures of employers.

Communication courses emphasize the mechanics of reading, writing, listening, speaking, and reporting. Instructors should establish standards of clarity, conciseness, and neatness in the beginning courses. In addition, instructors in technical courses should set increasingly high standards for student work in reporting. Freedom to report on technical subjects of their own choice may add reality and extra motivation for technology students. In the final phases of the 2-year program, the standards of reporting should approach those required by business organizations. At the same time, instructors should encourage individual style and initiative by allowing as much freedom as possible in reporting, consistent with established school standards. The judicious use of informal as well as formal reporting allows for training in the real situations encountered in employment, and adjusts the time required for writing formal reports to a reasonable portion of the student's schedule.

The course in Legal and Economic Aspects of Engineering logically follows the course in Industrial Organizations and Institutions and the cumulative study in the student's speciality, and is designed to provide important knowledge and a valid frame of reference for this area of the graduate civil technician's work.

Outside study is a significant part of the student's total program. In this curriculum, 2 hours of outside study time have been suggested for each hour of scheduled class time. A typical weekly work schedule for a student in the first semester of this curriculum would be: Class attendance, 15 hours; laboratory, 12 hours; outside, 30 hours—a total of 57 hours per week. This is a full schedule, but not excessive for this type of program. The second semester weekly schedule is 52 hours.

It should be noted that no examinations have been scheduled in the outlines. It is clearly intended that time be available for examinations. Therefore, a 17-week semester is assumed, and the outlines are designed to cover a full 16 weeks. The primary objectives of examinations are to evaluate the student's knowledge and to cause him to make a periodic comprehensive review of the material presented in the course.

The course outlines shown are concise and comprehensive, intended as guides rather than as specific plans of instruction to be covered in an inflexible order or sequence. They represent a judgment on the relative importance of each instructional unit, especially where time estimates are shown for the divisions within each course. It is expected that the principles outlined in these courses will be supplemented with industrial applications wherever possible. Industrial practices should be studied and followed in drafting and report writing, and materials from industry should be utilized throughout the program wherever it is possible to do so. Field trips will add greatly to the effectiveness of the instruction if they are carefully planned in advance and scheduled at a stage in the course where the construction or design operations observed will be understood in terms of the civil engineering and scientific principles being applied.

Throughout the program the student should be exposed to the general concept of ethical practices and professional ethics. This can be done more effectively by dealing with the ethical aspects of a problem as the problem is being discussed in the classroom than by having a separate course on ethics.

Suggested Continuing Study

A 2-year curriculum must concentrate on the primary needs of science, mathematics, and the related knowledge and skills of the technology necessary to preparing the student for employment upon graduation. Obviously, such a program of study cannot cover thoroughly in two years all of the subjects which are pertinent to the technology, and some important related subjects may be only touched upon in that time.

Some form of continuation of study for graduates of technology programs is therefore desirable. By reading the pertinent current literature the student can keep abreast of the technical developments of his special field, but this tends only to build on the organized technological base provided by the curriculum he studied.

Formal continuation by means of supplementary courses is the most efficient and practical way for the graduate technician to add important related areas of knowledge and skill to his initial education. Such courses have the advantages of systematic organization of subject matter, disciplined and competent teaching, and class discussion, and may be scheduled for evening or Saturday hours outside the graduate student's working day.

Continuation or extension courses for graduates of either option of this civil technology curriculum might include the following:

General and Industrial Economics
Hydraulics, Hydrology, and Drainage
Office Practices and Estimating
Structural Design and Detailing
Route Design and Surveys
Roadway Design and Construction
Applied Building Construction
Electronic Data Processing Programing and Application

Several of these courses are taught under one option but not under the other, and hence are listed here for postgraduate study.

COURSE OUTLINES

TECHNICAL COURSES—Both Highway and Structural Options

TECHNICAL DRAWING

Hours Required

Class, 1; Laboratory, 7; Credit, 4.

Description

An introductory course in engineering drawing and geometry. Use of instruments, orthographic projection, lettering, sectional views and auxiliary projections, and applied engineering geometry are studied to develop drafting and drawing knowledge and skills. Practice in these skills follows in studies of fasteners, dimensioning, and working and assembly drawings. A brief survey of pictorial sketching and drawing and making charts and diagrams is included.

Instruction Suggestions

It is suggested that this class meet for four 2-hour periods a week. The students should be expected to spend about 2 hours a week in studying the text assignment before coming to class, and the first 15 to 20 minutes of the class time usually may be devoted to an informal lecture-discussion of the assignment. The remainder of the period should be spent in making sketches or drawings involving this subject material. Most of the class plates should be one-period plates which are completed in the classroom. Some of the working drawings and assembly drawings may require more than one period; the plates may be collected at the end of each period and returned the following period until completed. At least one home plate, requiring a minimum of 2 hours to complete, should be assigned each week. The students should be required to do some inking and they should make drawings on a variety of types of paper such as ledger or vellum, and on mylar film and tracing cloth. The importance of good linework in order to obtain good reproductions should be stressed. Proper use of instruments and the need for neatness, accuracy, and completeness should also be emphasized. The students should be reminded constantly of the importance of good lettering. It is recommended that each plate contain some lettering for the students to do, and that they be graded on the lettering as well as the other content of the plate. The geometry problems should be practical, including work on structural steel shapes of the type the civil engineering technician is apt to encounter, and not merely theoretical.

	Hours	
Major Divisions	*Class*	*Laboratory*
I. Fundamentals	2	12
II. Orthographic Projection and Technical Sketching	2	14
III. Sectional Views	1	7
IV. Auxiliary Projections and Engineering Geometry	4	32
V. Fasteners	1	7
VI. Dimensioning	2	14
VII. Working and Assembly Drawings	1	11
VIII. Pictorial Drawings	2	10
IX. Charts and Diagrams	1	5
Total	16	112

I. Fundamentals.
  A. Class: 2 hours.
    1. Lettering.
      a. Styles in lettering.
      b. Freehand techniques.
      c. Lettering pencils and pens.
      d. Mechanical lettering guides.
    2. Drawing instruments.
      a. Use and care.
      b. Technique of drafting (pencil and ink).
      c. Templates for special symbols.
      d. Standard drawing-sheet types and sizes.
    3. Elementary geometrical constructions.

- B. Laboratory: 12 hours.
  - 1. Practice freehand engineering-style lettering exercises stressing weight, density, shape, style, slope, size, and spacing.
  - 2. Perform lettering exercises using mechanical lettering guides.
  - 3. Make mechanical drawings involving elementary geometrical constructions, such as a gasket. Use of instruments and pencil and ink techniques should be emphasized.

II. Orthographic Projection and Technical Sketching.

- A. Class: 2 hours.
  - 1. Theory of projection.
    - a. Types of projection.
    - b. Elements of projection.
  - 2. Orthographic projection.
    - a. Planes of projection.
    - b. Quadrants.
    - c. Position of object in relation to planes.
    - d. Selection of views.
    - e. Determination of visibility.
    - f. Projection of curved lines and surfaces.
    - g. Layout of multiview drawing.
    - h. Relationship of lines and planes to principal coordinate planes.
  - 3. Sketching.
    - a. Materials.
    - b. Technique.
    - c. Proportioning.
    - d. Multiview or orthographic sketching.
    - e. Isometric sketching.
    - f. Oblique sketching.
- B. Laboratory: 14 hours.
  - 1. Perform exercises on freehand sketching of straight and curved lines.
  - 2. Practice freehand sketching and scale drawings of simple objects. Make multiview drawings from isometric or oblique drawings and vice versa.
  - 3. Perform exercises involving missing lines and views.
  - 4. Perform exercises on relationships of lines and planes to principal coordinate planes.

III. Sectional Views.

- A. Class: 1 hour.
  - 1. Types of sections.
  - 2. Drawing views in section.
    - a. Section lining.
    - b. Material symbols in sections.
    - c. Hidden lines in sectional views.
    - d. Visible lines behind the section plane.
    - e. Structural members.
    - f. Thin sections.
    - g. Revolved and removed sections.
- B. Laboratory: 7 hours.
  Draw the missing sectioned view for various types of sections. These may be completion-type problems, or problems drawn completely by the student.

IV. Auxiliary Projections and Engineering Geometry.

- A. Class: 4 hours.
  - 1. Relation of auxiliary planes to principal planes and to the object—notation of auxiliary planes and views.
  - 2. Construction of principal views by auxiliary projection.
  - 3. Points—relation of points to each other.
  - 4. Lines.
    - a. True length.
    - b. Bearing and slope.
    - c. Piercing points.
    - d. Angles between lines.
    - e. Intersecting and parallel lines.
    - f. Vectors.
  - 5. Planes.
    - a. True size.
    - b. Intersection of two planes.
    - c. Angles between planes.
    - d. Distance between parallel planes.
    - e. Strike, dip, and outcrop.
    - f. Angles between lines and planes.
  - 6. Intersections.
    - a. Intersection of plane and prism or cylinder.
    - b. Intersection of plane and pyramid or cone.
    - c. Intersection of plane and double curved surfaces.

- d. Intersection of two cylinders.
- e. Intersection of cylinder and double curved surfaces.

7. Developments of surfaces.
   - a. Development of prism and cylinder.
   - b. Development of pyramid and cone.
   - c. Development of transition pieces.
   - d. Development by triangulation.
8. Warped surfaces.
   - a. Hyperbolic paraboloid.
   - b. Helicoid.

B. Laboratory: 32 hours.

1. Construct auxiliary views to show the true shape of inclined surfaces on objects.
2. Use auxiliary views to construct principal views.
3. Solve practical drawing problems involving the relationship between lines and planes. (Example: Find strike, dip, outcrop, and thickness of a stratum of rock.)
4. Draw a roof shaped as a hyperbolic paraboloid.
5. Draw a staircase in the shape of a helicoid.
6. Solve practical drawing problems involving intersections:
   - a. Intersection of culverts with fill on highway.
   - b. Intersection of large cylindrical pipes.
   - c. Intersection of cylindrical columns with double curved tank.
7. Develop prism, cylinder, pyramid, and cone.
8. Develop transition piece.

V. Fasteners.

A. Class: 1 hour.

1. Screw threads.
   - a. Nomenclature.
   - b. Types.
   - c. Thread series.
   - d. Classes of thread fit.
2. Representation of threads.
   - a. Conventional.
   - b. Simplified.
   - c. Schematic.
3. Representation of fasteners.
   - a. Bolts and nuts.
   - b. Rivets.
   - c. Welded joints.
4. Specification of threads and fasteners on drawings.

B. Laboratory: 7 hours.

Make detail representations of the common fasteners such as bolts, rivets, and welds. Pay attention to notes and specifications. Problems can be designed to involve fastener representation in sectioned views.

VI. Dimensioning.

A. Class: 2 hours.

1. General dimensioning.
   - a. Technique of how to dimension.
   - b. Placement of dimensions.
   - c. Dimensions required.
   - d. Dimensioning standard features.
   - e. Size dimensioning.
   - f. Location dimensioning.
   - g. Notes.
2. Shop terms and processes.
3. Tolerancing.

B. Laboratory: 14 hours.

1. Show dimensioning of simple machine parts (views furnished to students).
2. Show dimensioning of more complex structural members involving tolerance, fasteners, finished surfaces, decimal dimensioning, etc.

VII. Working and Assembly Drawings.

A. Class: 1 hour.

1. Working drawings.
   - a. Requirements for a complete working drawing.
   - b. Title block.
2. Assembly drawings.
   - a. Types.
   - b. Dimensioning and sectioning practices.
   - c. Listing of parts.

B. Laboratory: 11 hours.

1. Dimension properly a given highway structure, such as a simple reinforced concrete bridge pier. Show dimensions properly.
2. Study typical highway, structural, and building blueprints and note the location, placing, and dimension techniques that are required for fabrication and construction of the structure.

3. Make assembly drawing from working drawings.

VIII. Pictorial Drawings.

A. Class: 2 hours.

1. Isometric drawings.
   a. Theory of projection, including position of axes.
   b. Isometric drawings of plane figures involving straight and curved lines (four-center method of representing circles in isometric views).
   c. Isometric drawings of solids involving straight and curved lines.
   d. Isometric drawings of double curved surfaces.
   e. Dimensioning isometric drawings.
   f. Section views.
   g. Advantages and disadvantages of isometric representation.
2. Oblique drawings.
   a. Theory of projection.
      (1) General.
      (2) Cabinet.
      (3) Cavalier.
   b. Methods of constructing oblique drawings.
   c. Dimensioning oblique drawings.
   d. Sectioning oblique drawings.
   e. Advantages and disadvantages of oblique representation.

B. Laboratory: 10 hours.

Make isometric and oblique drawings of machine parts and parts of bridges or buildings such as expansion rollers, handrails, bridge piers, culverts, or other pertinent objects.

IX. Charts and Diagrams.

A. Class: 1 hour.

1. Use of charts.
2. Classification of charts and types of graph paper.
3. How to draw the chart.
   a. Selection of axes.
   b. Choice of scales.
   c. Marking coordinates.
   d. Showing plotted points.
   e. Drawing the curve.
   f. Titles.
   g. Sketches on the chart.

B. Laboratory: 5 hours.

Draw various types of charts and diagrams in pencil and ink. Some suggested problems are:

a. Plot curves showing the bending moment on a beam for various loads ($M = \frac{1}{8} wL^2$).
b. Draw stress-strain diagrams.
c. Draw a plane curve for a screen analysis.
d. Draw a soil profile.
e. Draw an organization chart.
f. Draw a bar chart comparing construction costs for the past 10 years.

TEXTS AND REFERENCES

Arnold and others. *Introductory Graphics*
Douglass and Hoag. *Descriptive Geometry*
French and Vierck. *Graphic Science*
———. *A Manual of Engineering Drawing for Students and Draftsmen*
Giesecke, Mitchell, and Spencer. *Technical Drawing*
Grant. *Practical Descriptive Geometry*
Hoelscher and Springer. *Engineering Drawing and Geometry*
———, ———, and Dobrovolny. *Basic Drawing for Engineering Technology*
Hood and Palmerlee. *Geometry of Engineering Drawing*
Luzadder. *Basic Graphics*
———. *Fundamentals of Engineering Drawing*
Paré. *Engineering Drawing*
——— and others. *Descriptive Geometry*
Rising and Almfeldt. *Engineering Graphics*
Spencer. *Basic Technical Drawing*
Springer, Bullen, Kleinhenz, and Palmer. *Basic Graphics: Drawing and Descriptive Geometry*
Warner and McNeary. *Applied Descriptive Geometry*
Wellman. *Technical Descriptive Geometry*
Zozzora. *Engineering Drawing*

VISUAL AND TRAINING AIDS

Bell & Howell Co., 7100 McCormick Ave., Chicago, Ill.
Cutting a Keyway on a Finished Shaft. 14 min., black and white
Fixed Gages. 16 min., 16 mm., black and white, sound
Laying Out Small Castings. 16 min., 16 mm., black and white, sound
Machining a Tool Steel V-Block. 19 min., black and white
Cutting an External Fine Thread. 11 min., black and white
Cutting Threads With Tapes and Dies. 17 min., black and white

Castle Films, Coronet Building, Chicago, Ill.
The Milling Machine. 7 min., black and white

Chicago Board of Education, 228 North La Salle St., Chicago, Ill.
The Draftsman. 11 min., 16 mm., black and white, sound
Coronet Films, Coronet Building, Chicago, Ill.
The Language of Graphs. 14 min., black and white
Film Production Co., 3650 Fremont Ave. North, Minneapolis, Minn.
Shop Drawing, Part I. 11 min., 16 mm., black and white, sound
Shop Drawing, Part II. 11 min., 16 mm., black and white, sound
Jam Handy Organization, 2900 East Grand Blvd., Detroit, Mich.
T-Squares and Triangles, Parts 1 and 2
Technical Lettering. Five filmstrips of 59, 53, 59, 77, and 57 frames, 35 mm., black and white
Behind the Shop Drawing. 18 min., 16 mm., black and white, sound
McGraw-Hill Book Co., Inc., 330 West 42d St., New York, N.Y., 10036
According to Plan: Introduction to Engineering Drawing. 9 min., black and white
Pictorial Sketching. 11 min., black and white
Orthographic Projection. 18 min., black and white
Selection of Dimensions. 18 min., black and white
The Drawing and the Shop. 15 min., black and white
Sections and Conventions. 15 min., black and white
Auxiliary Views: Single Auxiliaries. 23 min., black and white
Auxiliary Views: Double Auxiliaries. 13 min., black and white
Oblique Cones and Transition Development. 11 min., black and white
Simple Developments. 11 min., black and white
The Language of the Drawing. 10 min., black and white
Shape Description, Parts I and II. 11 min., 8 mm.
Size Description. 13 min., black and white
Auxiliary Views, Part I. 11 min., black and white
Auxiliary Views, Part II. 10 min., black and white
Intersections. 35 mm., filmstrips, 41 frames, color
Developments. 35 mm., filmstrips, 50 frames, color
Scales: Flat and Triangular. 35 mm., filmstrips, 37 frames, black and white
Pennsylvania State College, Film Library, State College, Pa.
Drafting Tips. 28 min., 16 mm., black and white, sound
Purdue Research Foundation, Lafayette, Ind.
Freehand Drafting. 12 min., 16 mm., black and white, silent
Testing of T-Square and Triangles. 11 min., 16 mm., black and white, silent
Use of T-Square and Triangles. 20 min., 16 mm., black and white, silent
Capital Letters. 21 min., 16 mm., black and white, sound
Lowercase Letters. 17 min., 16 mm., black and white, silent
Applied Geometry. 17 min., 16 mm., black and white, silent
Shape Description. 25 min., 16 mm., black and white, sound
Ink Work and Tracing. 31 min., 16 mm., black and white, silent
Sectional Views. 22 min., 16 mm., black and white, silent
Pictorial Drawing. 22 min., 16 mm., black and white, silent
Intersection of Surfaces. 10 min., 16 mm., black and white, silent
Stipes Publishing Co., 10 Chester St., Champaign, Ill.
35-mm. filmstrips, 27 frames each, black and white, with following titles:
Intersection of a Plane With Prisms and Pyramids
Intersection of a Plane With Curved Surface
Intersection of Prisms and Pyramids
Intersection of Single Curved Surfaces
Intersection of Two Cylinders
Intersection of Single With Double Curved Surfaces
Line Making Specified Angles With Two Planes, Construction Cones
Line Making Specified Angles With Two Lines, Construction Cones
Hyperbolic Paraboloid (Warped Quadrilateral)
Rolling Hyperboloids and Helicoids
United World Films, Inc., 1455 Park Ave., New York, N.Y.
Visualizing an Object. 9 min., 16 mm., black and White sound
Descriptive Geometry-Line of Intersection of Two Solids. 22 min., 16 mm., black and white, sound
University of Illinois, Audio Visual Aids, 909 South Sixth St., Champaign, Ill.
Design for Manufacture. 29 min., 16 mm., black and white, sound

CONSTRUCTION METHODS AND EQUIPMENT

HOURS REQUIRED

Class, 3; Laboratory, 0; Credit 3.

Description

An introductory study of methods to determine quantities of materials, equipment, labor, and money required for construction projects. It includes characteristics and capabilities of work equipment; methods of obtaining unit costs of in-place construction; and field reporting practices and responsibilities of field inspection.

Instruction Suggestions

Each group or type of equipment will be reviewed in the light of operating characteristics, capacities, and costs. Since time does not permit covering all units of equipment in a group, the instructor should select a representative unit and develop its operating and cost characteristics as typical of the analysis of other machines in that group. Extensive use should be made of films which are usually available from equipment manufacturers. A principal problem will be securing adequate text material to describe the various types of equipment. Generous use should be made of manuals and other materials produced by equipment manufacturers.

MAJOR DIVISIONS	Class hours
I. Introduction	2
II. Prime Movers	2
III. Earthwork and Excavation	8
IV. Subsurface Work	6
V. Materials Production	4
VI. Materials Handling and Erection	6
VII. Special Roadway Equipment	8
VIII. Cost Classification and Estimates	6
IX. Field Inspection	6
Total	48

I. Introduction.
  Class: 2 hours.
  1. Analysis of construction operations.
  2. Factors to consider in equipment planning and selection.
  2. Equipment characteristics: capacity, output, efficiency, cost.
  4. Analysis of equipment ownership and operating costs.
  5. Materials, equipment, and personnel scheduling for production.

II. Prime Movers.
  Class: 2 hours.
  1. Selection of motive power for job need; characteristics and costs.
  2. Steam boilers and engines.
  3. Internal combustion engines.
  4. Electric motors and generators.

III. Earthwork and Excavation.
  Class: 8 hours.
  1. Analysis of earthwork and equipment required; costs.
  2. Air compressors and air-operated tools.
  3. Rock drills and drilling.
  4. Blasting materials and their use.
  5. Tractor-type equipment and operations: tractive efforts, drawbar pull tractive and grade resistance.
  6. Bulldozer operation and production.
  7. Scraper operation and production.
  8. Tractor haul units and production.
  9. Power excavator units and production: balancing hauling unit with excavator.
  10. Dredges, cableways, trenchers, and other earthwork equipment.

IV. Subsurface Work.
  Class: 6 hours.
  1. Caissons, cofferdams, tunnel linings.
  2. Dewatering equipment: pumps and well points.
  3. Piledriving and extraction equipment.

V. Materials Production.
  Class: 4 hours.
  1. Aggregate production equipment.
  2. Screens and crushers.
  3. Bulk cement handling equipment.
  4. Bins, batchers, and mixers.

VI. Materials Handling and Erection.
  Class: 6 hours.
  1. Clamshells, elevators, and conveyors.
  2. Capabilities of cranes, derricks, hoists.
  3. Steel erection equipment; rivet hammers and passers; cutting and welding equipment.

VII. Special Roadway Equipment.
  Class: 8 hours.
  1. Concrete paving equipment.
  1. Bituminous paving equipment.
  3. Tract construction and maintenance equipment.

VIII. Cost Classification and Estimates.
  Class: 6 hours.
  1. Equipment scheduling.
  2. Methods of computing equipment costs.
  3. Cost of classification.
  4. Unit cost sources.
  5. Preparation of estimates.
  6. Contractor's control of costs.

IX. Field Inspection.
  Class: 6 hours.
  1. Duties and responsibilities.
  2. Labor laws and agreements.
  3. Inspector's reports.

TEXTS AND REFERENCES

Carson. *General Excavation Methods*
Engineering News-Record (Sections on Costs and Equipment)
McKaig. *Field Inspection of Building Construction*
Peurifoy. *Construction Planning, Equipment, and Methods*
———. *Estimating Construction Costs*
Power Crane and Shovel Association. *Technical Bulletins*

VISUAL AND TRAINING AIDS

Asphalt Institute, College Park, Md.
Asphalt Through the Ages. 13½ min., 16 mm., color, sound, 1957
The New Jersey Turnpike. 20 min., 16 mm., color, sound, 1951
Heavy-Duty Highways With Hot-Mix Asphalt. 25 min., 16 mm., color, sound, 1953
Barber-Greene Co., 400 North Highland Ave., Aurora, Ill.
The Finishing Touch (Barber-Greene paver). 16 mm., black and white, sound
Barber-Greene Model 845 Asphalt Plant. 16 mm., black and white, sound.
Caterpillar Tractor Co., Peoria, Ill.
Giant of the Earthmovers. 16 mm., color, sound.
Clark Equipment Co., Construction Machinery Div., Pipestone Rd., Benton Harbor, Mich.
Yardage Plus. 16 mm., sound
LeTourneau-Westinghouse Co., Peoria, Ill.
Let's Talk Tandems. 26 min., 16 mm., color, sound, 1963
Portland Cement Assoc.., 33 West Grand Ave., Chicago, Ill.
Building a Highway. 16 min., 16 mm., color, sound
Power Crane and Shovel Assoc., 74 Trinity Pl., New York, N.Y.
No. 1. *The Functional Design, Job Application and Job Analysis of Power Cranes and Shovels.* 16 mm., filmstrip, black and white, 1949
No. 2. *Estimating Costs of Ownership and Operations of Power Shovels, Hoes, Draglines, Clamshells and Cranes.* 16 mm., filmstrip, 1949
No. 3. *Power Size of Excavators.* 16 mm., filmstrip, black and white, 1949

SURVEYING AND MEASUREMENTS

Hours Required

Class, 2; Laboratory, 2; Field, 4; Credit, 4.

Description

An elementary course in surveying, including the fundamentals of plane surveying and the use and care of equipment. Accurate measuring of distance; theory and practice of leveling; angles and bearings; principles and use of the transit; curves; stadia; and topographic and land surveying are studied in coordinated class, laboratory, and field assignments. A brief introduction to the U.S. Public Lands System is included near the conclusion of the course. Special emphasis is placed on note-keeping and computations.

Instruction Suggestions

The prerequisite courses for this course are Technical Drawing and Technical Mathematics I.

It is not necessary to follow the sequence of the subject matter as shown in the detailed course outline. In cases where the geographical location of the school is such that extreme or inclement weather conditions occur early in the semester, the indoor work like computations, plotting, office details, lectures, and demonstrations may need to be given before any field work can be done. However, surveying is an outside activity, and effort should be made to do field work whenever possible.

Terrain selected for field problems should be rugged enough to introduce normal complexities but not to the point of requiring excessive time in execution. Areas used for surveys should be such that stakes for unfinished exercises can be left in place until the survey is completed, after which each survey party should remove the stakes and other markings.

Laboratory-field survey periods will generally be 3 hours twice a week, with a 2-hour period for class lectures and problem solving; however, this will also vary. Field work should approximate industrial practice, with proper stress on the degrees of precision required in good surveying practice. Field notes should be reduced to a convenient form for plotting or calculation of distances, areas, and volumes. Field notebooks should be kept according to good professional practice and errors of closure recorded. If a survey party on a field problem exceeds the permissible error, it should repeat the problem outside the regular class hours. Students should become proficient in the duties of each member of a survey party by rotating from position to position. They should be required to read and study the daily assignments as homework. It is also expected that the students will have some computations to finish outside of class time after having started them in the classroom.

	Hours		
MAJOR DIVISIONS	*Class*	*Laboratory*	*Field*
I. Introduction	3	0	0
II. Measurement of Distance	2	2	5
III. Leveling	3	4	12
IV. Angles and Bearings	2	4	0
V. Transit	3	4	14
VI. Horizontal and Vertical Curves	3	3	5
VII. Stadia Surveying	2	1	8
VIII. Use of the Plane Table	2	0	5
IX. Contours and Contour Construction	2	2	0
X. Topographic Surveying	2	0	7
XI. Route Survey	1	4	5
XII. Staking Out a Small Building	1	0	3
XIII. Computations	3	8	0
XIV. Land Surveying	3	0	0
Total	32	32	64

I. Introduction.

A. Class: 3 hours.

1. Definition of surveying.

2. Kinds and classes of surveys.

3. Precision and accuracy.

4. Field notes.

5. Errors and mistakes.

a. Distinction between errors and mistakes.

b. Distinction between precision and errors.

c. Classes of errors.

d. Reduction of errors.

6. Relation between angles and distances.

B. Laboratory Problems: 0 hours.

C. Field Problems: 0 hours.

II. Measurement of Distance.

A. Class: 2 hours.

1. Introductory remarks.

2. Units of length.

3. Instruments.

a. Steel and metallic tapes.

b. Steel pins.

c. Spring balance and clamp handle.

d. Range poles.

e. Care of equipment.

4. Pacing and stadia method.

5. Measuring with steel tape: level ground.

6. Measuring with steel tape: sloping or uneven ground.

a. Tape held level.

b. Tape placed on ground.

7. Errors in taping.

a. Incorrect length.

b. Temperature.

c. Slope and alinement.

d. Setting pins.

e. Tension and wind.

8. Mistakes in taping.

a. Omitted tape length.

b. Misreading the tape.

c. Calling and recording numbers.

d. 1-foot mistakes.

e. Mistaking end marks.

9. Checks.

10. Accuracy, specifications, note-keeping, and corrections for temperature and other variables.

B. Laboratory Problems: 2 hours.

Problem-solving exercises, to be completed as homework.

C. Field Problems: 5 hours.

1. Practice taping and pacing on level ground around a known traverse, forward and back.

2. Practice taping on sloping ground:

a. Tape level, slope estimated.

b. Tape on ground, correction applied.

Accuracy must be within allowable limits. If not, field problems are to be repeated.

III. Leveling.

A. Class: 3 hours.

1. Need for relative elevation of points on earth's surface.

2. General principles of leveling.

3. Earth's curvature and atmospheric refraction.

4. Three methods of leveling.

5. Engineer's level: Dumpy and Wye types.

a. Telescope.

(1) Objective lens.

(2) Eyepiece.

(3) Crosshairs.

(4) Parallax.

(5) Magnification.

b. Bubble-tube.

   c. Tangent and clamp screws.
   d. Leveling screws and footplate.
   e. Tripod.
6. Self-leveling level.
7. Level rods.
8. Care of equipment.
   a. Carrying of instrument.
   b. Screws and clamps.
   c. Lenses.
   d. Crosshairs.
   e. Moisture.
9. Theory of leveling.
   a. Bench mark.
   b. Turning point.
   c. Backsight.
   d. Height of instrument.
   e. Foresight.
10. Field procedure.
   a. Makeup of party members.
   b. Setting up level.
   c. Obtaining field information.
11. Differential leveling.
   a. Obtaining complete and proper field notes—check.
   b. Precautions to observe.
      (1) Centering the bubble.
      (2) Keeping rod plumb.
      (3) Equal backsight and foresight distances.
   c. Signals used by members of party.
12. Adjustment of the engineer's level.
   a. Relations that should exist.
   b. Adjustment of the crosshair ring.
   c. Adjustment of the bubble-tube.
   d. Adjustment of the line of sight.
   e. Tests to be made for maladjustment and adjustments, and neutralization procedures needed for specific instruments.
13. Sources of error in leveling.
   a. Nonadjustment of instrument.
   b. Bubble not centered.
   c. Incorrect reading of rod.
   d. Rod not plumb.
   e. Incorrect rod length.
   f. Parallax.
   g. Curvature of the earth.
   h. Heat waves and wind.
   i. Settling of the instrument.
   j. Poor turning points.
14. Mistakes commonly made in leveling.
   a. Misreading the rod.
   b. Recording and computing.
15. Checks, and balancing procedures.
16. Accuracy and specifications.

B. Laboratory Problems: 4 hours.
   Problem-solving exercises, to be completed as homework.

C. Field problems: 12 hours.
   1. Measure a differential level circuit—short—one-fourth mile.
   2. Measure a differential level circuit—long—2 miles.
   3. Test an instrument—tests and results are to be recorded.
   4. Demonstrate profile leveling.

   All field problems are to be repeated if not checked within allowable accuracy.

IV. Angles and Bearings.
A. Class: 2 hours.
   1. General remarks and definitions.
   2. Closed and open traverses.
      a. Interior, exterior, deflection, reentrant angles, and angle to the right.
      b. Bearings.
         (1) Meridians—magnetic, true and assumed.
         (2) Declination.
         (3) Magnetic bearing.
         (4) True bearing.
      c. Geodetic azimuths.
         Azimuth and back azimuth.
   3. The compass and its use.
      a. Reading a bearing.
      b. Calculating bearings from angles and angles from bearings.
      c. Sources of errors.
         (1) Parallax.
         (2) Needle not straight or sluggish.
         (3) Local attractions.
         (4) Variations of declination.
      d. Mistakes.
         (1) Misreading the quadrant letters.
         (2) Transposing the quadrant letters.
         (3) Misreading the circle.
      e. Accuracy.

  - B. Laboratory Problems: 4 hours.
    Problem-solving exercises, to be completed as homework.
  - C. Field Problems: 0 hours.
- V. Transit.
  - A. Class: 3 hours.
    1. General remarks.
    2. Description of the transit; types in general.
       - a. Use of instrument and teaching aids.
       - b. Care of instrument.
    3. Definition of terms as applied to transit work.
       - a. Orientation.
       - b. Backsight and foresight.
       - c. Normal or direct position.
       - d. Inverted position.
       - e. Reversal of the instrument.
       - f. Horizontal and vertical axis.
       - g. Upper and lower motions.
    4. Vernier and its use.
       - a. Linear and circular scales.
       - b. Vernier readings.
    5. Setting up transit for use.
       - a. Instrument leveled.
       - b. Instrument centered over fixed point.
    6. Measuring horizontal angles.
    7. Prolonging a straight line.
    8. Measuring vertical angles.
    9. Measuring angles by repetition.
    10. Laying off angles by repetition.
    11. Tests and adjustments of the transit.
        - a. Plate-bubble tubes.
        - b. Crosshair ring.
        - c. Line of sight.
        - d. Standards.
        - e. Telescope bubble-tube.
        - f. Vertical arc.
    12. Sources of error.
        - a. Imperfect adjustment of transit.
        - b. Reading the vernier.
        - c. Sighting and parallax.
        - d. Setting over point.
        - e. Soft ground.
        - f. Weather conditions.
    13. Mistakes.
        - a. Misreading verniers.
        - b. Reading wrong vernier.
        - c. Reading wrong circle and incorrectly.
        - d. Using wrong tangent screw.
        - e. Recording.
  - B. Laboratory Problems: 4 hours.
    Problem-solving exercises, to be completed as homework.
  - C. Field Problems: 14 hours.
    1. Practice reading angles and bearings about a point.
    2. Study an interior angle closed traverse; magnetic bearing.
    3. Make a closed azimuth traverse; magnetic bearing, calculate interior angles and bearings.
    4. Perform a deflection angle traverse; distance by stadia rod (horizontal distances).
    5. Determine an angle by repetition.
    6. Practice the prolongation of a straight line—1,200 feet.
    7. Test and adjust a transit—tests and results are to be recorded.

    Field problems not checked within allowable accuracy are to be repeated.
- VI. Horizontal and Vertical Curves.
  - A. Class: 3 hours.
    1. Horizontal circular curves.
       - a. Definitions.
       - b. Trigonometric and geometric relationships.
       - c. Relation between radius and degree of curvature.
       - d. Deflection angles.
       - e. Calculation and staking out of curve.
       - f. Transit at a station on a curve.
       - g. Offsetting.
    2. Vertical curves.
       - a. Mathematical principles.
       - b. Vertical curve computation.
       - c. Road and pavement crowns.
  - B. Laboratory Problems: 3 hours.
    Problem-solving exercises, to be completed as homework.
  - C. Field Problems: 5 hours.
    1. Calculate and lay out short curve from P. C. (300′).
    2. Calculate and lay out longer curve from two points on curve.

Both curves are to be recorded in field notebook and checks and errors of closure are to be indicated. Field problems not checked within allowable error are to be repeated.

VII. Stadia Surveying.
  A. Class: 2 hours.
    1. Stadia instruments and method.
    2. Stadia theory.
      a. Principle.
      b. Stadia constants.
      c. Interval factor.
      d. Horizontal sights.
    3. Inclined sights.
      a. Trigonometric relations.
      b. Reduction of stadia notes.
    4. Transit-stadia traversing.
    5. Stadia leveling.
    6. Locating details.
    7. Sources of error.
      a. Reading rod; rod not plumb; length of rod.
      b. Vertical angle.
      c. Instrument constant.
      d. Parallax.
      e. Natural errors: wind, temperature, or other.
    8. Accuracy.
      a. Traversing: 1 in 500 to 1 in 2,000.
      b. Leveling: $\pm 0.4\sqrt{\text{miles}}$ to $\pm 2.0\sqrt{\text{miles}}$.
  B. Laboratory Problems: 1 hour.
    Problem-solving exercises, to be completed as homework.
  C. Field Problems: 8 hours.
    Perform a transit-stadia traverse and leveling for locating details and contours. (This would be a contour map problem.)

VIII. Use of the Plane Table.
  A. Class: 2 hours.
    1. General information concerning the plane table and alidade.
    2. Setting up and orienting instrument.
    3. Traversing.
    4. Principle of intersection.
    5. Principle of resection.
    6. Triangulation.
    7. Locating details.
    8. Tests and adjustment of the alidade.
    9. Sources of error.
      a. Settling over point and sighting.
      b. Drawing in field.
      c. Instability of table and alidade.
    10. Accuracy, checks.
    11. Comparison of plane table and transit methods.
    12. Principles of the Beaman arc.
  B. Laboratory Problems: 0 hours.
  C. Field Problems: 5 hours.
    Lay out a triangular traverse (minimum) and locate some details.

IX. Contours and Contour Construction.
  A. Class: 2 hours.
    1. Characteristics of contours and contour lines.
    2. Systems of contour points.
    3. Contour line construction.
    4. Contour map studies.
    5. Field methods of procuring information for contours.
  B. Laboratory Problems: 2 hours.
    Problem-solving exercises, to be completed as homework.
  C. Field Problems: 0 hours.

X. Topographic Surveying.
  A. Class: 2 hours.
    1. General remarks.
    2. Horizontal control.
      a. Traverse.
      b. Triangulation.
    3. Vertical control.
    4. Accuracy of map.
    5. Scale of map.
    6. Contour interval.
    7. Specifications.
  B. Laboratory Problems: 0 hours.
  C. Field Problems: 7 hours.
    1. Use transit-stadia traverse from item VII C.
    2. Locate topographic and manmade features.

XI. Route Survey.
  A. Class: 1 hour.
    1. Discuss field procedure of assigned problem.
    2. Discuss office procedure of assigned problem.
  B. Laboratory Problems: 4 hours.
    Draw a plan and profile and compute

some earthwork volumes, using data from field problem. Complete as homework.

C. Field Problem: 5 hours.

Make a centerline profile survey of an existing road locating details. Cross-section profiles are to be taken at least at every full station. This problem may be extended to replace existing road with a "new" one so that cut and fill earth is involved.

XII. Staking Out a Small Building.

- A. Class: 1 hour.
  1. Set temporary stakes for corners of building.
  2. Measure diagonals for check.
  3. Set batter-boards at determined grade.
  4. Determine alinement across batter-boards.
  5. Set reference points.
- B. Laboratory Problem: 0 hours.
- C. Field Problems: 3 hours.

  Do as a class project: Lay out a small nonrectangular building of predetermined size and shape. Assign survey parties to specific tasks so that each student will have an opportunity to participate and become acquainted with all the field procedures.

XIII. Computations.

- A. Class: 3 hours.
  1. Methods of computation.
     - a. Accuracy.
     - b. Significant figures.
  2. Computation of distances.
  3. Computation of areas.
     - a. By triangles.
     - b. By coordinates.
     - c. Latitudes and departures.
     - d. The DMD method.
  4. Theory of rectangular coordinates.
  5. Areas of cross-sections.
     - a. Three-level.
     - b. Five-level.
  6. Areas with irregular boundaries.
     - a. Trapezoidal rule.
     - b. Simpson's one-third rule.
     - c. Coordinate method.
     - d. Polar planimeter.
  7. Earthwork computations.
     - a. Volumes by average land area methods.
     - b. Volumes of prismoids.
     - c. Borrow pits.
- B. Laboratory Problems: 8 hours.

  Problem-solving exercises, to be completed as homework.
- C. Field Problems: 0 hours.

XIV. Land Surveying.

- A. Class: 3 hours.
  1. U.S. Public Lands System.
     - a. Historical remarks.
     - b. Meridians and baselines.
     - c. Township subdivision.
     - d. Section subdivision.
     - e. Quarter section subdivision.
     - f. Corners.
  2. Legal aspects.
     - a. Authority of surveyor.
     - b. Kinds of deed descriptions.
     - c. Requirements of valid descriptions.
       - (1) Accuracy.
       - (2) Brevity.
       - (3) Clarity.
  3. Obliterated and lost corners.
  4. Deed survey.
- B. Laboratory Problems: 0 hours.
- C. Field Problems: 0 hours.

TEXTS AND REFERENCES

Bouchard and Moffitt. *Surveying*
Breed. *Surveying*
Brown. *Boundary Control and Legal Principles*
Davis. *Elementary Plane Surveying*
——— and Foote. *Surveying: Theory and Practice*
Kissam. *Surveying for Civil Engineers*
Laurila. *Electronic Surveying and Mapping*
Meyer. *Route Surveying*
Pickels and Wiley. *Route Surveying*
Rayner. *Elementary Surveying*
Rubey. *Route Surveys and Construction*
Smirnoff. *Measurements for Engineering, and Other Surveys*
Taylor and Brinker. *Elementary Surveying*
Theroux and Smith. *Plane Surveying*
U.S. Department of Commerce, Coast and Geodetic Survey. *Sines, Cosines, and Tangents; Ten Decimal Places—0 Degrees to 6 Degrees—Lambert Projections*
———. *The State Coordinate Systems*
———. Topographic sheets (of school area)
U.S. Department of Interior, Bureau of Land Management. *Restoration of Lost or Obliterated Corners and Subdivision of Sections*
Wattles. *Land Survey Descriptions*

VISUAL AND TRAINING AIDS

U.S. Department of Commerce, Bureau of Public Roads, Photographic Dept. Washington, D.C., 20235

Safety in Highway Surveying, 25 min., 16 mm., color, sound

SOILS AND FOUNDATIONS

Hours Required

Class, 2; Laboratory, 3; Credit, 3.

Description

This course covers the criteria used in the selection, design, and construction of the elements of a structure that transfers its total load to the underlying formations. Theoretical aspects considered and treated are: Analysis of subsoil conditions; bearing capacity and settlement analysis; character of natural soil deposits; earth pressure and retaining wall theory; and stability of slopes and subgrades. Basic types of prevalent foundations, their design and behavioral characteristics are also covered.

Instruction Suggestions

A principal objective of the course is to develop in the student a basis of judgment in relating the load-bearing qualities of soils to the design methods used for load distribution. Sufficient time is provided for laboratory exercises to permit tests on more than one soil type and soil sample. The study of films, where available, can be a useful method of demonstrating various aspects of the course, especially subsurface exploration, foundation types and construction methods.

Major Divisions	*Hours* *Class*	*Laboratory*
I. Properties of Subsurface Materials	7	27
II. Subsurface Exploration	3	12
III. Foundation Types and Construction Methods	12	0
IV. Foundation Types: Field Interpretation of Design	5	9
V. Structural Design of Foundation Elements	5	0
Total	32	48

I. Properties of Subsurface Materials.
  A. Class: 7 hours.
    1. Index properties of soils and rocks.
    2. Weight volume relations.
    3. Structure and consistency of soil aggregate.
    4. Permeability.
    5. Intergranular and porewater pressures.
    6. Water content, drainage, frost action.
    7. Stress-strain characteristics; sands and clays.
    8. Shearing resistance: sands, silts, clays, rock.
    9. Stability of slopes and cuts.
  B. Laboratory: 27 hours.
    1. Make a Standard Proctor (moisture-chemistry relationship) Test (2 periods).
    2. Make a Modified Proctor Density Test.
    3. Make relative density tests in the field.
    4. Make a California Bearing Ratio Test (2 periods).
    5. Study hydraulic properties; make tests of permeability.
    6. Make falling head permeability tests.
    7. Make compressibility and consolidation tests.
    8. Make tests for unconfined compressive strength.

II. Subsurface Exploration.
  A. Class: 3 hours.
    1. Techniques of subsurface exploration.
    2. Character of natural deposits.
    3. Exploration programs.
    4. Field determination of strength characteristics.
  B. Laboratory: 12 hours.
    1. Demonstrate subsurface exploration equipment.
    2. Practice field use of exploration equipment by obtaining soil samples.

III. Foundation Types and Construction Methods.
  A. Class: 12 hours.
    1. Excavation and bracing.
    2. Stabilization and drainage.
    3. Roadway foundations.
    4. Footing and raft foundations.
    5. Pile foundations.
    6. Pier foundations and pier shafts.
    7. Abutments and retaining walls.
    8. Underpinning and shoring.
  B. Laboratory: 0 hours.

VISUAL AND TRAINING AIDS

U.S. Department of Commerce, Bureau of Public Roads, Photographic Dept. Washington, D.C., 20235

Safety in Highway Surveying, 25 min., 16 mm., color, sound

SOILS AND FOUNDATIONS

HOURS REQUIRED

Class, 2; Laboratory, 3; Credit, 3.

Description

This course covers the criteria used in the selection, design, and construction of the elements of a structure that transfers its total load to the underlying formations. Theoretical aspects considered and treated are: Analysis of subsoil conditions; bearing capacity and settlement analysis; character of natural soil deposits; earth pressure and retaining wall theory; and stability of slopes and subgrades. Basic types of prevalent foundations, their design and behavioral characteristics are also covered.

Instruction Suggestions

A principal objective of the course is to develop in the student a basis of judgment in relating the load-bearing qualities of soils to the design methods used for load distribution. Sufficient time is provided for laboratory exercises to permit tests on more than one soil type and soil sample. The study of films, where available, can be a useful method of demonstrating various aspects of the course, especially subsurface exploration, foundation types and construction methods.

	Hours	
MAJOR DIVISIONS	*Class*	*Laboratory*
I. Properties of Subsurface Materials	7	27
II. Subsurface Exploration	3	12
III. Foundation Types and Construction Methods	12	0
IV. Foundation Types: Field Interpretation of Design	5	9
V. Structural Design of Foundation Elements	5	0
Total	32	48

I. Properties of Subsurface Materials.
  A. Class: 7 hours.
    1. Index properties of soils and rocks.
    2. Weight volume relations.
    3. Structure and consistency of soil aggregate.
    4. Permeability.
    5. Intergranular and porewater pressures.
    6. Water content, drainage, frost action.
    7. Stress-strain characteristics; sands and clays.
    8. Shearing resistance: sands, silts, clays, rock.
    9. Stability of slopes and cuts.
  B. Laboratory: 27 hours.
    1. Make a Standard Proctor (moisture-chemistry relationship) Test (2 periods).
    2. Make a Modified Proctor Density Test.
    3. Make relative density tests in the field.
    4. Make a California Bearing Ratio Test (2 periods).
    5. Study hydraulic properties; make tests of permeability.
    6. Make falling head permeability tests.
    7. Make compressibility and consolidation tests.
    8. Make tests for unconfined compressive strength.

II. Subsurface Exploration.
  A. Class: 3 hours.
    1. Techniques of subsurface exploration.
    2. Character of natural deposits.
    3. Exploration programs.
    4. Field determination of strength characteristics.
  B. Laboratory: 12 hours.
    1. Demonstrate subsurface exploration equipment.
    2. Practice field use of exploration equipment by obtaining soil samples.

III. Foundation Types and Construction Methods.
  A. Class: 12 hours.
    1. Excavation and bracing.
    2. Stabilization and drainage.
    3. Roadway foundations.
    4. Footing and raft foundations.
    5. Pile foundations.
    6. Pier foundations and pier shafts.
    7. Abutments and retaining walls.
    8. Underpinning and shoring.
  B. Laboratory: 0 hours.

IV. Foundation Types: Field Interpretation of Design.
  A. Class: 5 hours.
    1. Selection and bearing capacity of site.
    2. Foundations on sand.
    3. Foundations on clay.
    4. Foundations on silt and loess.
    5. Foundations on nonuniform soils.
    6. Damage due to construction operations.
    7. Field inspection of construction operations.
  B. Laboratory: 9 hours.
    Analyze foundation behavior on different types of soil.

V. Structural Design of Foundation Elements.
  A. Class: 5 hours.
    1. Column and wall footings.
    2. Footings subject to moment.
    3. Combined footings and rafts.
    4. Retaining walls and abutments.
  B. Laboratory: 0 hours.

TEXTS AND REFERENCES

Bauer and Thornburn. *Introductory Soil and Bituminous Testing*
Hough. *Basic Soils Engineering*
Iowa State Technical Institute. *Laboratory Manual: Soils Technology*
Peck and others. *Foundation Engineering*
Sowers and Sowers. *Introductory Soil Mechanics and Foundations*
Taylor. *Fundamentals of Soil Mechanics*
Terzaghi and Peck. *Soil Mechanics in Engineering Practice*
U.S. Department of Interior, Bureau of Reclamation. *Earth Manual*

VISUAL AND TRAINING AIDS

U.S. Department of Commerce, Bureau of Public Roads, Photographic Dept., Washington, D.C., 20235
Highway Soil Engineering.—3 films, total 1 hr. 50 min., 16 mm., color, sound

REINFORCED CONCRETE CONSTRUCTION

HOURS REQUIRED

Class, 3; Laboratory, 2; Credit, 4.

Description

This course includes study of properties of concrete, elementary stress calculations, and the specifications for columns, beams, and slabs. The construction considerations include forming, shoring, reinforcing, and the relationship between construction cost and design.

Instruction Procedures

The course is intended to develop in the student an understanding of properties of concrete as a material and their relations to specification, design, and construction. Laboratory work will consist of problem solution and graphic presentation in the subjects named. Emphasis is placed on why designs reflect certain principles and practices, and the permissible tolerances and departures from those practices.

	Hours	
MAJOR DIVISIONS	*Class*	*Laboratory*
I. Materials for Reinforced Concrete	5	0
II. Concrete Columns	7	6
III. Concrete Beams	9	8
IV. Slab Reinforcement	7	6
V. Construction Procedures	17	6
VI. Estimating	3	6
Total	48	32

I. Materials for Reinforced Concrete.
  A. Class: 5 hours.
    1. Properties of materials.
    2. Concrete as a material.
    3. Properties and types of reinforcing steel.
    4. Specifications for steel.
  B. Laboratory: 0 hours.

II. Concrete Columns.
  A. Class: 7 hours.
    1. Types of columns.
    2. Elementary stress calculations.
    3. Behavior and resulting specifications.
    4. Reinforcement in tied and spiral columns.
    5. Detail for reinforcing steel.
  B. Laboratory: 6 hours.
    1. Make stress calculations for a concrete column. Include eccentric and combined loading.
    2. Show a good reinforcing design for a concrete column.

III. Concrete Beams.
  A. Class: 9 hours.
    1. Influence of building codes on design and construction.

  2. Flexure, shear, bond and diagonal tension.
  3. Elementary stress calculations.
  4. Longitudinal and stirrup reinforcement.
- B. Laboratory: 8 hours.
  1. Make stress calculations for concrete beams.
  2. Show a good reinforcing design for concrete beams.

IV. Slab reinforcement.
- A. Class: 7 hours.
  1. Slabs.
  2. Rigid frames.
  3. Footings.
  4. Continuous girders.
  5. Nomenclature.
- B. Laboratory: 6 hours.
  1. Show a good reinforcing design for concrete slabs.
  2. Prepare drawings of reinforcing for several concrete slabs.

V. Construction Procedures.
- A. Class: 17 hours.
  1. Typical members in structures.
  2. Methods of forming and shoring.
  3. Lift slab procedures.
  4. Relation between construction methods and design.
  5. Prestressing procedures.
  6. Practical considerations in placing reinforcing elements.
  7. Precast slabs.
  8. Placing concrete.
  9. Types of finish for surfaces.
  10. Equipment for placing and finishing concrete.
  11. Field inspection.
  12. Curing practices and requirements.
- B. Laboratory: 6 hours.
  1. Sketch a design of forming and shoring for a concrete structure involving a slab, under two columns, supporting a horizontal beam.
  2. Study field inspection practices.

VI. Estimating.
- A. Class: 3 hours.
  1. Quantity takeoffs.
  2. Unit prices.
- B. Laboratory: 6 hours.
  1. Compute quantities of material for structure in V, B, 1, above.
  2. Prepare estimates of the cost of materials and labor for the structure in VI, B, 1, above.

TEXTS AND REFERENCES

American Concrete Institute. *Publication No. 318–63*
Boguslavsky. *Design of Reinforced Concrete*
Champion. *Failure and Repair of Concrete Structures*
Concrete Reinforcing Steel Institute. *CRSI Design Handbook*
Ferguson. *Reinforced Concrete Fundamentals*
Parker. *Simplified Design of Reinforced Concrete*
Peabody. *The Design of Reinforced Concrete Structures*
Peurifoy. *Construction Planning, Equipment, and Methods*

ADVANCED DRAFTING FOR HIGHWAY TECHNOLOGY

Hours Required

Class, 1; Laboratory, 7; Credit, 4

Description

This course acquaints the student with drafting room procedures and methods used in map drawing and in the graphical presentation of steel and concrete structures. Emphasis is placed on drawing topographic maps, plans and profiles, and cross-sections. The detailing of steel and reinforced concrete members of bridges, piers, trestles, retaining walls, and culverts is stressed. The student also becomes familiar with materials and nomenclature associated with design and drafting operations.

Instruction Suggestions

It is suggested that this class meet for four 2-hour periods a week. The length of informal lecture-discussions will vary from period to period depending upon the topic being considered that day, and there will probably be several periods where no lecture or discussion is required. It is recommended that class plates be drawn entirely in the classroom and that home plates require a minimum of 2 hours of work a week. Class plates which require more than one period to draw may be picked up by the instructor at the end of each period and returned the following period. The student should be expected to spend an average of 2 hours a week in studying text assignments. As in the beginning drawing course, the importance of good lettering and linework and the proper use of instruments, neatness, accuracy, and completeness should be emphasized. Information for the map-drawing problems should be presented in the form of field notes as obtained by the surveyor. The major portion of the structural drawing problems should relate to members and structures commonly encountered in highways, railway, or airport construction. The topographic map should be laid out in pencil and then finished in ink or scribed. The other plates should all be drawn with pencils.

	Hours	
Major Divisions	*Class*	*Laboratory*
I. Map Drawing	5	35
II. Structural Steel Drawing	7	41
III. Reinforced Concrete Drawing	6	34
Total	18	110

I. Map Drawing.
  A. Class: 5 hours.
    1. Classification of maps.
      a. Geographic.
      b. Topographic.
      c. Cadastral.
      d. Engineering.
    2. Map scales.
    3. Map symbols.
      a. Size and prominence.
      b. How to draw.
      c. Spacing.
      d. Position.
      e. Special symbols.
      f. Colors.
    4. Contour lines.
      a. Characteristics of contour lines.
      b. Plotting contour lines from field data.

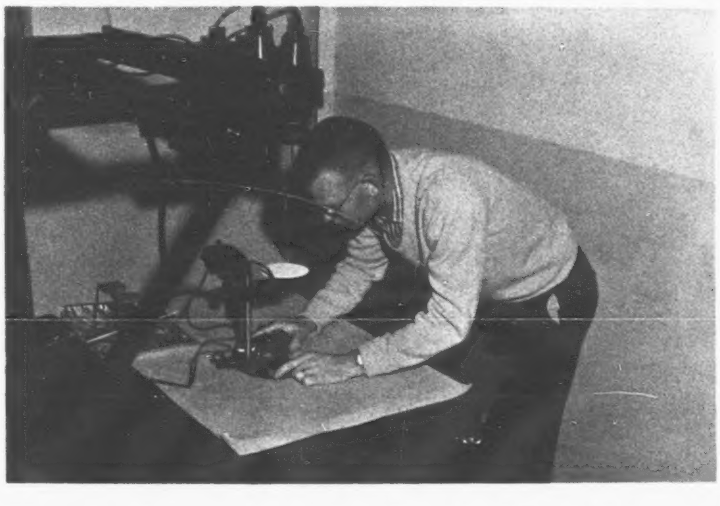


Figure 5.—Because of the extensive adoption of photogrammetric measurement in recent years the highway technician needs an understanding of the principles and practices associated with photogrammetry. This technician is operating a multiplex stereoplotter.

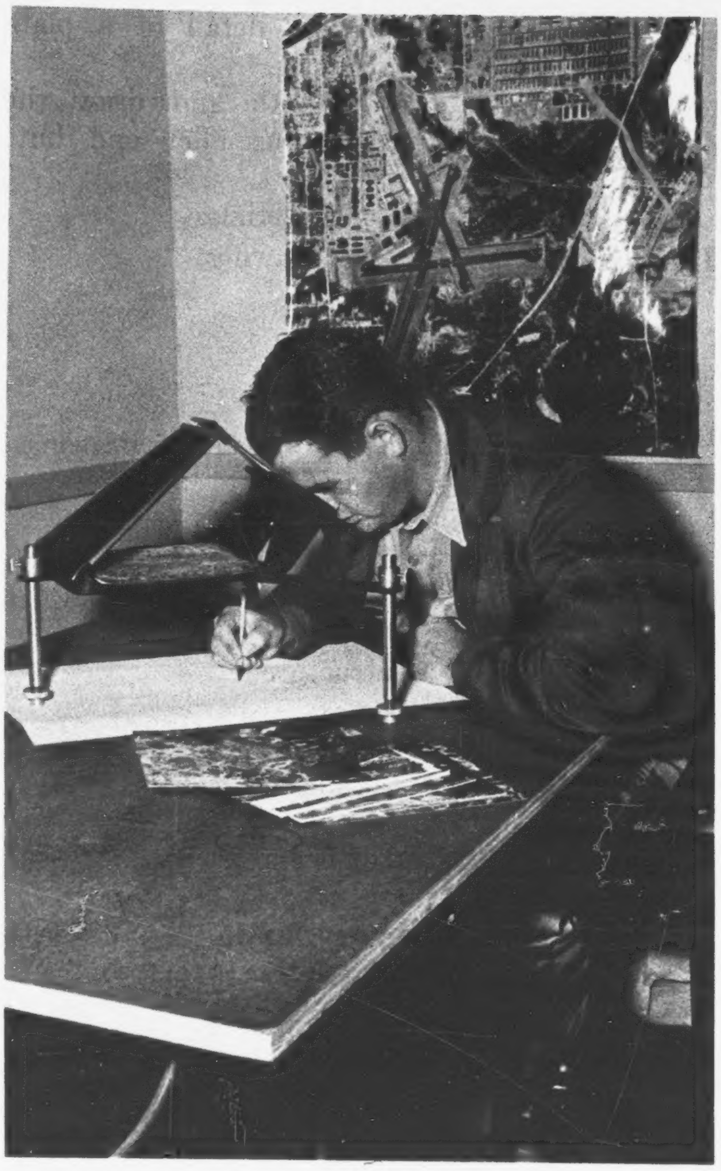


Figure 6.—**This vertical sketchmaster is a device which permits the technician to transfer accurate detail information from aerial photographs to blueprint tracing paper.**

c. Marking elevations of contour lines.
d. Contour interval.
e. Use of contour maps.
f. Hachures.
5. Plotting a map traverse and details.
a. Rectangular coordinate method.
b. Tangent method.
c. Protractor and scale method.
d. Horizontal curves.
6. Map titles.
7. Profiles.
a. Plotting from field data.
b. Plotting of curved lines.
c. Plotting of vertical curves.
d. Plotting of grade line.
e. Plotting of ground, tangent, and finished grade elevation.
f. Existing and proposed drainage, structures, and other prominent details.
8. Cross-section.
a. Plotting from field data.
b. Plotting of cut and fill.
c. Plotting of areas.
d. Plotting of template on sections.
B. Laboratory: 35 hours.
1. Draw typical symbols.
2. Draw contour lines from points plotted by various methods.
3. Figure watershed area from contour map.
4. Draw topographic map from field notes.
5. Draw plan and profile for section of highway.
6. Draw cross-sections for portion of highway.
7. Determine cut and fill volumes.
II. Structural Steel Drawing.
A. Class: 7 hours.
1. Definitions of common terms used in structural steel work such as bay, bent, cope, purlin, gusset plate, pitch, etc.
2. Standard structural shapes.
a. Dimensions.
b. Weights.
c. Properties.
d. Rolling mill practices.
3. Types of structural steel drawings.
a. Detail sketches.
b. Layouts.
c. Framing plans.
d. Details.
e. Column schedules.
f. Erection diagrams.
g. Connections.
4. Conventions in structural steel drawings.
a. Number and location of views.
b. Scales.
c. Details.
d. Bottom view.
e. Symmetrical members.
f. Sectional views.

5. Dimensioning.
    a. Techniques.
    b. Placing of dimensions.
    c. Fabricating dimensions.
6. Marking.
    a. Assembly marks.
    b. Erection marks.
    c. Right- and left-hand members.
7. Rivets and bolts.
    a. Size.
    b. Spacing.
    c. Symbols.
    d. Gage line and pitch.
    e. Allowable loads.
8. Welding.
    a. Welding process.
    b. Fillet.
    c. Butt.
    d. Strength and size.
    e. Symbols.
9. Standard connections.
    a. Standard beam connections.
    b. Seated connections.
10. Bevels—Inskip's or Smoley's Tables.
11. Billing materials.
    a. In notes.
    b. In a bill of materials.
12. Fabricating operations.
    a. Template making.
    b. Laying out.
    c. Punching.
    d. Drilling.
    e. Fitting and reaming.
    f. Cutting, shearing, and sawing.
    g. Straightening, bending, and rolling.
    h. Milling.
    i. Riveting.
    j. Welding.
    k. Painting.

B. Laboratory: 41 hours.
1. Draw standard structural shapes where the student has to fill in dimensions, using AISC Manual.
2. Detail steel beams with standard connections with and without cope.
3. Figure slopes and lengths of members of a bridge truss.
4. Make layouts of joints of bridge truss.
5. Detail some members of bridge truss.
6. Detail a steel column.
7. Make a complete detail of a plate girder.
8. Figure the strength and draw the symbols for various fillet and butt welds.
9. Make a bill of materials.

III. Reinforced Concrete Drawing.

A. Class: 6 hours.
1. Drawing standards.
    a. Sizes.
    b. Scales.
    c. Recommended layout for drawings.
    d. Designations.
    e. Symbols.
    f. Abbreviations.
    g. Lines.
2. Marking.
    a. Parts of structure.
    b. Bars.
3. Schedules.
    a. Horizontal and vertical.
    b. Information shown.
    c. Typical bar bends.
4. Reinforcing bars.
    a. Plain and deformed.
    b. Welded wire fabric.
    c. Spirals.
    d. Standard sizes.
    e. Weight.
    f. Standard hooks.
    g. Slant lengths.
    h. Spacing.
    i. Splices.
    j. Ties.
    k. Stirrups.
    l. Dowels.
    m. Fabrication tolerances.
5. Dimensioning.
    a. Techniques.
    b. Placing of dimensions.
    c. Number, size, length, bending details and spacing of bars.
    d. Size and location of concrete members.
6. Types of reinforced concrete drawings.
    a. Engineering.
    b. Placing.
    c. Combined engineering and placing.
7. Bar supports.
    a. Specifications.
    b. Standard nomenclature.

8. Composite construction.
9. Bar lists.

B. Laboratory: 34 hours.

1. Make a detail drawing of a reinforced concrete deck girder span and abutment.
2. Make a detail drawing of a reinforced concrete pier.
3. Make a detail drawing of a reinforced concrete retaining wall.
4. Make a detail drawing of a reinforced concrete culvert.
5. Make some bar lists.

TEXTS AND REFERENCES

American Concrete Institute. *Manual of Standard Practice for Detailing Reinforced Concrete Structures*
American Institute of Steel Construction. *Manual of Steel Construction*
———. *Structural Shop Drafting*
Bishop. *Structural Drafting*
Concrete Reinforcing Steel Institute. *A Manual of Standard Practice for Reinforced Concrete Construction*
Giesecke, Mitchell, and Spencer. *Technical Drawing*
Hoelscher and Springer. *Engineering Drawing and Geometry*
Inskip. *Inskip's Tables*
Luzadder. *Fundamentals of Engineering Drawing*
Rising and Almfeldt. *Engineering Graphics*
Sloane and Montz. *Elements of Topographic Drawing*
Smoley. *Tables; . . . For Engineers, Architects, and Students*
U.S. Department of the Interior, Geological Survey. *Topographical Map Symbol Sheet*
———. *Topographical Maps*
U.S. War Department. *Conventional Signs, Military Symbols, and Abbreviations*
———. *Topographical Drafting*

VISUAL AND TRAINING AIDS

Bethlehem Steel Co., Bethlehem, Pa.
  Man, Steel, and Earthquakes (fabricated steel). 28 min., 16 mm., color, sound
  Steel in Concrete (reinforcing bars). 38 min., 16 mm., color, sound
  Steel Spans the Chesapeake (bridge building). 37 min., 16 mm., color, sound
Purdue Research Foundation, Lafayette, Ind.
  Structural Drawing. 20 min., 16 mm., black and white, silent
U.S. Department of the Interior, Bureau of Mines, Washington, D.C., 20240
  The Story of Arc Welding. 25 min., 16 mm., color, sound
United States Steel Corp., Public Relations Dept., 208 South La Salle St., Chicago, Ill.
  Building for the Nations. 35 min., 16 mm., color, sound
  The Cantilever Bridge. 25 min., 16 mm., sound
  The Suspension Bridge. 26 min., 16 mm., sound
United World Films, Inc., 1445 Park Ave., New York, N.Y.
  Introduction To Map Projection. 18 min., black and white, sound

PHOTOGRAMMETRY

Hours Required

Class, 1; Laboratory, 3; Credit, 2.

Description

This course is an elementary introduction to the principles, equipment, techniques, and applications of photogrammetry as used in highway design and construction. It begins with a study of the principles of photogrammetry and aerial photography; proceeds to photointerpretation, displacement calculations and stereoscopic measurements; and concludes with studies of applications in radial line plotting, tax map preparation, and mosaic construction.

Instruction Suggestions

It is desirable that the course consist of 1 hour of lecture, followed by a 3-hour laboratory session per week. The student should have completed the course in Surveying and Measurements prior to enrolling.

The first meeting will, of necessity, be all lecture and no laboratory. This meeting will probably require 2 to 3 hours of lecture. Thereafter, the class time is to be devoted to theory and explanations of the work to be done by the student in the laboratory period following. With some topics (such as Stereoscopic Measurements), after the preliminary explanations have been made the entire 4 hours of the following periods may be devoted to laboratory exercises.

The instructor must have readily available aerial photographs taken with a forward overlap of approximately 60 percent, made with a precision aerial camera whose focal length is 6 inches. The use of U.S. Agriculture Department photographs taken with an 8¼″ focal length camera is discouraged. A set of three 9″ x 9″ aerial photos taken in sequence with this 60-percent overlap is needed for each student. These 9″ x 9″ photos preferably should be at a scale of 1″=500′±. Horizontal and vertical controls are necessary. Local area photos should be used, if obtainable, to allow students to observe on the ground the work done on the photos. Many cities and counties have had photographic coverage for topographic mapping or planning purposes or for highway locations. The appropriate agencies in these areas can be contacted to determine where the negatives are located, so that prints may be obtained. Most State highway departments will be able to furnish photographs for various locations throughout the State. If photographs are unobtainable from any of these sources, a photogrammetry laboratory kit may be used.

An enlarged photo of a local area is needed for each student to work on in preparing a tax map. A U.S. Department of Agriculture photo may be used for this. The recommended scale of this enlargement is 1″=400′, if a rural area is used; 1″=200′ or 1″=100′, depending upon the density of tracts of land, if a suburban area is chosen; 1″=50′ or 1″=100′ for an urban area, again dependent upon the density of the tracts. The instructor should determine the owners of the various tracts (from the local tax assessor's office), give these names to the students (3–5 to each student), and have the students look up the deed descriptions and any plats on record in the local office which registers deeds. These deeds and plats should then be compiled by the instructor into sets of mimeographed deeds to be given to the students to plot. The deeds and plats can be plotted directly on the enlargement and then traced, in ink, on a sheet of cronoflex or mylar placed over the enlargement, and the plotting can be done directly on the cronoflex or mylar and then inked. The latter method allows the enlargement to be used more than once.

The instructor should have a number of photos showing various landforms and manmade structures for identification purposes in studying Photo Interpretation. These photos can be passed around during the laboratory period for the students to observe. Objects should be circled on the front of the photos and identified on the back.

The 9″ x 9″ contact prints can be used to view stereoscopically with a small folding lens-type stereoscope having a small parallax bar attachment for determining differences of elevation. It is recommended that elevations of two easily identifiable points be given, a graph plotted, and elevations of other easily identifiable points obtained by the students. Two or three stereocomparagraphs can be used also. Proper scheduling will allow each student to use these instruments at least 2 hours. Two or more class periods should be used to explain the stereoscopic plotters. The anaglyph may be used to demonstrate how a stereoscopic model is formed. A field trip should be taken to the nearest photogrammetric laboratory and the students allowed to see first hand how stereoscopic mapping machines operate, and the various operations carried on by a government agency or privately owned company.

A number of photos (approximately 12–16), preferably with two-flight lines, should be available for each student to prepare an uncontrolled mosaic. These may be surplus photos obtained from some government agency or private firm, or may be photos purchased from the Map Information Office, Geological Survey, U.S. Department of Interior, Washington, D.C., 20250. These do not necessarily need to be photos of the local area.

	Hours	
MAJOR DIVISIONS	*Class*	*Laboratory*
I. Introduction	1	3
II. Flight Planning	1	3
III. Photo Interpretation	1	3
IV. Displacement Calculations	1	3
V. Stereoscopic Measurements	4	12
VI. Radial Line Plot	2	6
VII. Tax Map Preparation	4	12
VIII. Mosaic Construction	2	6
Total	16	48

I. Introduction.
  A. Class: 1 hour.
    1. Uses of aerial photos and maps.
    2. Types of maps, mosaics, etc., used in engineering and planning.
    3. Relative costs of ground and aerial mapping.
    4. Agencies with available photography and maps.
    5. Ground controls necessary.
    6. Methods of obtaining photography.
    7. Cameras.
  B. Laboratory: 3 hours.
    Complete the discussions listed under "class."

II. Flight Planning.
  A. Class: 1 hour.
    1. Scale-flight altitude-camera focal length relations.

  2. Overlap and number of photos.
  3. Side lap, spacing, and number of flight lines.
  4. Total number of negatives to cover an area.
  5. Flight maps.
- B. Laboratory: 3 hours.
  Calculate flight line spacing, number of photos, draw flight lines on map of a given area.

III. Photo Interpretation.
- A. Class: 1 hour.
  1. Planimetric features.
  2. Topographic features.
  3. Soils and geologic features.
  4. Foliage patterns.
  5. Classification and numbers of structures.
  6. Traffic densities.
  7. Seasonal differences.
- B. Laboratory: 3 hours.
  Examine various features on aerial photos illustrating features discussed in class period.

IV. Displacement Calculations.
- A. Class: 1 hour.
  1. Factors causing distortion, displacements and scale differences in photos.
  2. Displacements due to relief.
- B. Laboratory: 3 hours.
  Make displacement calculations due to relief.

V. Stereoscopic Measurements.
- A. Class: 4 hours.
  1. Stereoscopes.
  2. Theory of elevation determination by parallax measurements.
  3. Orientation of photos for stereoscopic viewing.
  4. Explanation of parallax bars and parallax measurements.
  5. Graphical determination of elevations from photos.
  6. Stereoplotters.
- B. Laboratory: 12 hours.
  1. Study orientation, stereoscopic viewing, and determination of elevations, using stereoscopes and parallax bars (3 periods).
  2. Visit a photogrammetry laboratory.

VI. Radial Line Plot.
- A. Class: 2 hours.
  Explanation of graphical radial triangulation on photos to locate control points or construct maps.
- B. Laboratory: 6 hours.
  Prepare a map showing street patterns using graphical radial triangulations (2 periods).

VII. Tax Map Preparation.
- A. Class: 4 hours.
  Explanation of construction and use of tax maps.
- B. Laboratory: 12 hours.
  1. Perform a deed research in office of local register of deeds.
  2. Study and demonstrate deed plotting on photo enlargement.
  3. Prepare a finished tax map.

VIII. Mosaic Construction.
- A. Class: 2 hours.
  Types of mosaics and their construction.
- B. Laboratory: 6 hours.
  Prepare an uncontrolled aerial mosaic.

TEXTS AND REFERENCES

American Congress on Surveying and Mapping. *Surveying and Mapping* (Quarterly)

American Society of Civil Engineers. *Civil Engineering* (Quarterly)

American Society of Photogrammetry. *Manual of Photogrammetry*

———. *Manual of Photographic Interpretation*

———. *Photogrammetric Engineering* (Quarterly)

Breed, Hosmer, and Bone. *Principles and Practice of Surveying*, Vol. I.

Davis and Foote. *Surveying: Theory and Practice*

Eichler and Tubis. *Photogrammetry Laboratory Kit*

Hallert. *Photogrammetry*

Kissam. *Surveying for Civil Engineers*

Moffitt. *Photogrammetry*

Rubey and others. *Engineering Surveys: Elementary*

Spurr. *Photogrammetry and Photo-Interpretation*

U.S. Department of Commerce, Bureau of Public Roads. *Specifications for Aerial Surveys and Mapping by Photogrammetric Methods for Highways*

DRAINAGE AND GEOLOGY

Hours Required

Class, 3; Laboratory, 3; Credit, 4.

Description

A study of the basic theory of the hydraulics of flow in pipes and in open channels including also the hydrology of drainage areas, storm water runoff, and streamflow analysis. Design concepts and techniques cover subsurface drainage and storm drainage structures such as ditch checks, conduit systems, and bridges, with major emphasis on culverts.

Instruction Suggestions

Examples and illustrations should be selected to relate the course material to the drainage problems of roadways, bridges, and buildings. The first section, on fluid mechanics, should present illustrations and examples based on piping and other equipment used in buildings and factories for water supply, sewage, and transfer of liquid products. Some flexibility in time allotment is permissible here if a class is composed primarily of building technology students. The emphasis on drainage design for roadway structures will relate to culvert openings and small drainage areas (of 6,000 acres or less), but will not omit entirely the problems of large areas and openings.

	Hours	
MAJOR DIVISIONS	*Class*	*Laboratory*
I. Basic Fluid Mechanics	12	15
II. Geology of Streams	10	0
III. Drainage	6	9
IV. Concepts of Design and Procedures	12	15
V. Flow Through Culverts and Bridges	8	9
Total	48	48

I. Basic Fluid Mechanics.
  A. Class: 12 hours.
    1. Properties of fluids.
    2. Pressures.
    3. Bouyancy.
    4. Bernoulli Equation—ideal fluids.
    5. Reynolds number.
    6. Darcy-Weisbach equation.
    7. Losses at bends, exits, and entrances.
    8. Hydraulic and energy gradients.
    9. Long pipelines.
    10. Operation of centrifugal pumps.
    11. Manning equation.
    12. Specified energy.
    13. Critical depth.
    14. Nonuniform flow.
    15. Surface profiles.
  B. Laboratory: 15 hours.
    1. Study problems in manometry.
    2. Study and illustrate hydraulic and energy gradients.
    3. Study and calculate friction in pipes (study use of friction nomographs).
    4. Study uniform flow in open channels.
    5. Study the backwater curve in an open channel.
II. Geology of Streams.
  A. Class: 10 hours.
    1. Nature of the hydrologic cycle.
    2. Precipitation, intensity, duration, frequency.
    3. Ground water.
    4. Infiltration capacity.
    5. Runoff and factors affecting same and storage.
    6. Stream channel, growth and flow.
    7. Channel shape and maximum velocity.
    8. Channel systems.
    9. Stream's profiles.
    10. Valley cross-profiles and development.
    11. Stream's load, chemical and physical.
    12. Delta.
    13. Stages in history of a stream system.
    14. Characteristics of landscapes as developed.
  B. Laboratory: 0 hours.
III. Drainage.
  A. Class: 6 hours.
    1. Need for surface drainage.
    2. Runoff computation; Burkle-Ziegler formula.
    3. Determination of drainage area.
    4. Drainage structures; culverts and bridges for surface drainage.
    5. Highway subdrainage.
  B. Laboratory: 9 hours.
    1. Define and solve a rainfall and runoff problem.
    2. Demonstrate the use of the Thessen and Ischyetal methods in solving drainage problems.
    3. Illustrate rational method design problem.
IV. Concepts of Design and Procedures.
  A. Class: 12 hours.
    1. Permeability and seepage paths.
    2. Drainage and drain rivers.

3. Subdrains and filters.
4. Streamflow data.
5. Annual hydrographs and variability.
6. Flow duration curves.
7. Partial duration series flood study.
8. Base flow.
9. Unit hydrograph theory.
10. Unit hydrograph application.
11. S curve.
12. Design flood.
13. Flood routing.
14. Flood attenuation.
15. Empirical flood equations.
16. Historical flood analysis.

B. Laboratory: 15 hours.
1. Define and give solution of a subsurface drainage problem.
2. Illustrate a duration curve design problem.
3. Solve a unit hydrograph and flood frequency problem.

V. Flow through Culverts and Bridges.

A. Class: 8 hours.
1. Culvert system.
2. Hydraulics of culverts.
3. Culverts with exit control.
4. Culverts with barrel control.
5. Culverts with entrance control.
6. Stream morphology.
7. Capacity of bridges.
8. Contracted opening theory.
9. Backwater at bridges.

B. Laboratory: 9 hours.
1. Demonstrate a culvert problem involving a mild slope.
2. Demonstrate a culvert problem involving a steep slope.
3. Demonstrate a culvert problem involving a steep slope with a submerged outlet.

TEXTS AND REFERENCES

Armco Drainage and Metal Products, Inc. *Handbook of Drainage and Construction Products*
King. *Handbook of Hydraulics*
King, Wisler, and Woodburn. *Hydraulics*
Linsley, Kohler, and Paulhus. *Hydrology for Engineers*
Vennard. *Elementary Fluid Mechanics*
Wisler and Brater. *Hydrology*

ROADWAY DESIGN AND CONSTRUCTION

Hours Required

Class, 3; Laboratory, 4; Credit, 4.

Description

This course is concerned with the elements of a transportation roadway and their functions: Roadway foundations; pavement types, characteristics, composition, and structural design; construction procedures; and characteristics of railroad tracks and beds.

Instruction Suggestions

Emphasis should be given to the roadway as an integrated structure, showing the relations between subgrade, base course (or ballast section), and pavement (or track). Principles of design are basic to an understanding of fieldwork and reasons for construction methods. Considerations of load-bearing capacity, load distribution, and stability are important. The subjects of earthmoving, aggregate and concrete production, pavement laying and railroad work equipment will have been covered already in the course in Construction Methods and Equipment. Route location and geometric layout (including railroad turnouts) will be covered concurrently in Route Design and Surveys. Liberal use should be made of films to show both design and construction procedures. The subject of organization for construction and maintenance in the track section should be presented concurrently with the other topics rather than as a separate item.

The laboratory work recommended for this course is a comprehensive location-construction design problem that will be a summation of the materials covered in this and associated courses. There should be two 2-hour laboratory periods a week. The problem should encompass the design of a complete section of highway and/or airport runway. It should include both the so-called flexible and rigid types of pavements and the subgrade design and construction procedures appropriate to each. The alinement, profile, earthwork, drainage, construction methods and equipment, estimate of costs, and any other pertinent features that time permits should be included. A section of the report should also cover in brief detail how the foregoing subgrade design could be adapted to railroad use. The progress of the problem should be paced so as to stay slightly behind the classroom presentation, thereby allowing the new materials of the course to be included. The final laboratory report should be complete with drawings, sample calculations, estimate sheets, and other features of a comprehensive report.

MAJOR DIVISIONS	*Hours*	
	Class	*Laboratory*
I. Introduction	2	2
II. Roadway Foundations	10	12
III. Pavement Surface Properties	3	4
IV. Composition Design of Flexible Pavements	10	14
V. Structural Design of Concrete Pavements	10	14
VI. Pavement and Subgrade Construction	7	12
VII. Railroad Track and Bed	6	6
Total	48	64

I. Introduction.
  A. Class: 2 hours.
    1. Problems in roadway design and construction.
    2. Roadway elements: pavements and uses.
    3. Elastic character of roadway structures.
    4. Importance of drainage.
  B. Laboratory: 2 hours.
    1. Give introduction to project.
    2. Begin paper location and plan of project.

II. Roadway Foundations.
  A. Class: 10 hours.
    1. Factors affecting subgrade support in the frost zone (frost action, soil expansion and shrinkage, settlement, lateral flow, elasticity, pumping, erosion).
    2. Applications of surface and subsurface drainage facilities to the solution of soil problems.
    3. Consolidation, displacement and excavation methods for handling unstable soil areas.
    4. Effects of compaction control on subgrade uniformity and slope stability.
    5. Subbase stabilization methods.
    6. Base course design, stabilization and placement.
    7. Culvert and bridge abutment backfilling procedures and problems.
  B. Laboratory: 12 hours.
    1. Design alinement and profile.
    2. Complete paper location and plan of project.
    3. Design cross-section and compute earthwork.

III. Pavement Surface Properties.
  A. Class: 3 hours.
    1. Durability and effects of skid resistance.
    2. Smoothness.
    3. Light reflection and resistance to glare.
    4. Tractive resistance.
    5. Loose materials.
  B. Laboratory: 4 hours.
    Design surface and subdrainage systems of project.

IV. Composition Design of Flexible Pavements.
  A. Class: 10 hours.
    1. Effects of static and impact loadings on flexible surfaces.
    2. Factors affecting stability and durability.
    3. Design and placement of pavement materials.
    4. Initial and maintenance costs of low-cost and bituminous surfaces.
  B. Laboratory: 14 hours.
    1. Design foundation for "flexible-type" pavement for project.
    2. Design "flexible-type" pavement for project.

V. Structural Design of Concrete Pavements.
  A. Class: 10 hours.
    1. Effects of static and impact loading.
    2. Fatigue.
    3. Expansion, contraction, warping.
    4. Surface wear and air entrained cement concrete.
    5. Pumping and frost action.
    6. Internal chemical reactions.
    7. Fill settlement effects.
    8. Joint design and use.
  B. Laboratory: 14 hours.
    1. Design foundation for "rigid-type" pavement for project.
    2. Design "rigid-type" pavement for project.

VI. Pavement and Subgrade Construction.
  A. Class: 7 hours.
    1. Inspection and testing requirements, problems, and procedures.
    2. Sequence of construction operations (using films showing bituminous and concrete construction operations).
  B. Laboratory: 12 hours.
    1. Revise foregoing designs for airport runways and standings.
    2. Write program of construction procedure, equipment, and schedules.

VII. Railroad Track and Bed.
  A. Class: 6 hours.
    1. Railroad subgrades.
    2. Purpose and design of ballast sections.
    3. Use and design of crossties.
    4. Rails and fastenings.
    5. Bending stresses and flexure in track.
    6. Shearing and contact stresses in rail.
    7. Roadbed stabilization.
    8. Organization for construction and maintenance.
  B. Laboratory: 6 hours.
    1. Revise the foregoing project for railroad track.
    2. Prepare cost estimates for railroad modification of project.

TEXTS AND REFERENCES

Hay. *Railroad Engineering*
Hennes and Ekse. *Fundamentals of Transportation Engineering*
Hewes and Oglesby. *Highway Engineering*
Martin and Wallace. *Design and Construction of Asphalt Pavements*
Ritter and Paquette. *Highway Engineering*

VISUAL AND TRAINING AIDS

U.S. Department of Commerce, Bureau of Public Roads, Photographic Dept., Washington, D.C., 20235
  AASHO Road Test film report No. 1. 27 min., 16 mm., color, sound
  AASHO Road Test film report No. 2. 37 min., 16 mm., color, sound
  AASHO Road Test film report No. 3. 14 min., 16 mm., color, sound
  Precast Concrete Bridge. 18 min., 16 mm., color, sound

ROUTE DESIGN AND SURVEYS

Hours Required

Class, 2; Laboratory, 4; Credit, 4.

Description

This course in highway route design is concerned with the effects of traffic and vehicular characteristics on road design, length of highway, curvature and elevation of roadbeds as they affect costs and location; geometric design; field and office practice in route and curve layout; earthwork computations; and the principles of aerial photography applied to highway route design.

Instruction Suggestions

The sequence of subject matter and weekly time separation between classroom and laboratory instruction will have to be varied to meet changing weather conditions. Laboratory field survey periods will be generally 3 to 4 hours once a week. Fieldwork should approximate industrial practice and standards. Degrees of precision should be stressed. Field notebooks should be kept according to good professional practice; errors of closure should be recorded whenever possible. Terrain selected for field problems should be rugged enough to introduce normal complexities but not to the point of requiring excessive time. Areas used for surveys should be such that stakes for unfinished exercises can be left in place until finished, after which each survey group should remove its stakes and markings. Supplementary texts may be necessary to cover all topics.

Work with the theodolites, subtense bars, and self-leveling levels must be scheduled carefully. Three laboratory field parties should work with the theodolites, while the other three parties work with the self-leveling levels; then a switch of the instruments is made at the next laboratory period. A mockup of the geodimeter, tellurometer and electrotape can be used to demonstrate methods of operation. A field demonstration should be arranged for one or more of these instruments, possibly by the State Highway Department.

	Hours	
Major Divisions	*Class*	*Laboratory*
I. Factors in Engineering Location	6	8
II. Simple Curves	5	8
III. Spiral Curves	7	12
IV. Vertical Curves and Grades	4	4
V. Earthwork	3	16
VI. Modern Instruments	7	16
Total	32	64

I. Factors in Engineering Location.
  A. Class: 6 hours.
    1. Traffic flow and surveys.
    2. Route and intersection capacities.
    3. Vehicle characteristics.
    4. Effects of distance on location and costs.
    5. Effects of curvature on location and costs.
    6. Effects of grades and elevation on location and costs.
    7. Location procedures.
  B. Laboratory: 8 hours.
    1. Study full-scale highway plans obtainable from State highway departments for an understanding of highway problems.
    2. Use U.S. Geological Survey maps of school areas (scale 1:24,000) to affect the preliminary location of a highway. Plan and profile studies can be made from data taken directly from the map.

II. Simple Curves.
  A. Class: 5 hours.
    1. Review of curve functions.
    2. Office and field procedures in curve layout.
    3. Special curve problems—inaccessible PI, PC, or PT, curve through a fixed point, sight distance.
    4. Change-of-location problems.
    5. Compound and reverse curves.
  B. Laboratory: 8 hours.
    1. Make a simple layout; locate PI, PC, PT—set up at PC and run curve to PT with stakes at regular stations.
    2. Project a simple curve through a fixed point using intermediate setup and stakes at regular and 50 ft. stations.
    3. Survey a compound curve (stakes at regular intervals on D_1 curve and at regular stations and +50s on D_2 curve).

III. Spiral Curves.
  A. Class: 7 hours.
    1. Spiral characteristics and functions; the cubic parabola.
    2. Application to simple curves.
    3. Application to compound curves.
    4. Application to railroad uses; superelevation.
    5. Application to highway uses; superelevation and pavement widening.
    6. Highway interchanges.
  B. Laboratory: 12 hours.
    1. Study the relation of spiral to circle—to show the rate at which a spiral departs from an osculating circle.
    2. Lay out a spiraled simple curve—stakes at 50-ft. intervals on spiral; locate PI, TS, and ST; run first spiral to the SC; run circle to CS; back in second spiral for ST to CS.
    3. Lay out a spiraled compound curve, including a spiral connecting the two simple curves in the compound.
    4. Lay out a highway spiral and superelevation by setting grade stakes on the proposed edges of a superelevated and spiraled highway pavement and stretching strings from one side of the pavement to the other. The concurrent development of spiral and superelevation can be observed.

IV. Vertical Curves and Grades.
  A. Class: 4 hours.
    1. Layout of gradelines.
    2. Properties of parabolic curves.
    3. Length of vertical curves.
    4. High, low, and specific points on curve.
    5. Applications to railroads—permissible lengths.
    6. Applications to highways—sight distance.
    7. Applications to airport runways.
  B. Laboratory: 4 hours.

V. Earthwork.
  A. Class: 3 hours.
    1. Design of cross sections; shape, height, width, slope; effects of soil characteristics.
    2. Cross sectioning and slope stakes.
    3. Volumetric computations; average end area and prismoidal formulas.
    4. Balancing of cut and fill; mass diagram.
    5. Set up for machine computation.
  B. Laboratory: 16 hours.
    1. Make a preliminary route survey; establish centerline and bench marks; cross sections over short length of route. Plot cross sections and compute volume.

2. Solve a problem in slope stakes. Given assigned profile, gradeline, bench marks, and side slopes, field parties will set required slope stakes and compute areas of cross section.
3. Make a mass diagram. Working in drafting laboratory with assigned cross section data, prepare mass diagram and determine earthwork distribution and hauling distances; prepare estimate of cost.

VI. Modern Instruments.
   A. Class: 7 hours.
      1. Use of optical reading theodolites.
      2. Use of the subtense bar.
      3. Precise leveling methods.
      4. Surveying altimeters.
      5. Electronic measuring devices.
         a. Geodimeter.
         b. Tellurometer.
         c. Electrotape.
         d. Others, as they are developed.
   B. Laboratory: 16 hours.
      1. Study traversing, using the theodolite.
      2. Study distance measuring with the subtense bar.
      3. Study precise levels, using USGS yard rod and methods.
      4. Report on the demonstration of electronic measuring device.
      5. Make appropriate calculations of geodimeter, tellurometer, and electrotape notes.

TEXTS AND REFERENCES

Hay. *Railroad Engineering*
Hickerson. *Route Surveys and Design*
Ives. *Highway Curves*
Matson, Smith, and Hurd. *Traffic Engineering*
Meyer. *Route Surveying*
Pickets, and Wiley. *Route Surveying*
Rayner. *Elementary Surveying*
Ritter, and Paquette. *Highway Engineering*
Rubey. *Route Surveys and Construction*
U.S. Department of Commerce, Coast and Geodetic Survey. *Manual of Plane Coordinate Computation*, Special Publication No. 193

TECHNICAL COURSES—*Structural Option Only*

ADVANCED DRAFTING FOR STRUCTURAL TECHNOLOGY

Hours Required

Class, 2; Laboratory, 8; Credit, 5.

Description

Course in drafting room procedures and methods used in architectural drawing and in graphical presentation of steel and concrete structures. Emphasis is placed on working drawings in architecture and on detailing structural steel and reinforced concrete members of buildings. Students will also become familiar with structural materials and with the nomenclature used in civil engineering.

Instruction Suggestions

It is suggested that this class meet for five 2-hour periods a week. The length of informal lecture-discussion will vary from period to period depending upon the topic being considered that day, and there will probably be several periods where no lecture or discussion is required. It is recommended that class plates be drawn entirely in the classroom and that home plates require a minimum of 4 hours of work a week. Class plates which require more than one period to draw may be picked up by the instructor at the end of each period and returned the following period. The student should be expected to spend an average of 2 hours a week in studying text assignments. As in the beginning drawing course, the importance of good lettering and linework, the proper use of instruments, neatness, accuracy, and completeness should be emphasized. The architectural portion of this course should concentrate on working drawings rather than on preliminary sketches or display drawings. The structural portion should concentrate on the preparation of detail drawings for steel and reinforced concrete members and structures commonly encountered in building construction. Inkwork, if any, should be held to a minimum.

Major Divisions	Hours	
	Class	*Laboratory*
I. Architectural Drawing	6	30
II. Structural Steel Drawing	14	53
III. Reinforced Concrete Drawing	12	45
Total	32	128

I. Architectural Drawing.
  A. Class: 6 hours.
    1. General classes of architects' drawings.
      a. Preliminary sketches and display drawings.
      b. Working drawings.
    2. Types of working drawings and information provided by each.
      a. Plot plans
      b. Basement and/or foundation plans.
      c. Floor plans.
      d. Elevations.
      e. Sections.
      f. Details.
      g. Structural framing plans.
      h. Plans for mechanical, electrical, plumbing, heating, and ventilating work.
    3. Standard details.
      a. Standard materials—Sweet's *Architectural File.*
      b. Standard methods of construction.
    4. Technique of architectural drawing as compared to machine drawing.
    5. Conventional symbols.
    6. Dimensioning.
      a. Technique.
      b. Where to place dimensions.
      c. What dimensions to give.
    7. Notes.
    8. Specifications.
      a. Items covered.
      b. References used in preparation, such as Sweet's *Architectural File.*

B. Laboratory: 30 hours.
   Draw a floor plan, elevation, and typical wall section of a small factory building or similar structure.

II. Structural Steel Drawing.
- A. Class: 14 hours.
  1. Definitions of common terms used in structural steel work, such as bay, bent, cope, purlin, gusset plate, pitch, etc.
  2. Standard structural shapes.
     - a. Dimensions.
     - b. Weights.
     - c. Properties.
     - d. Rolling mill practice.
  3. Types of structural steel drawings.
     - a. Detail sketches.
     - b. Layouts.
     - c. Framing plans.
     - d. Details.
     - e. Column schedules.
     - f. Erection diagrams.
  4. Conventions in structural steel drawings.
     - a. Number and location of views.
     - b. Scales.
     - c. Details.
     - d. Bottom view.
     - e. Symmetrical members.
     - f. Sectional views.
  5. Dimensioning.
     - a. Techniques.
     - b. Placing of dimensions.
     - c. Fabricating dimensions.
  6. Marking.
     - a. Assembly marks.
     - b. Erection marks.
     - c. Right- and left-hand members.
  7. Rivets and bolts.
     - a. Size.
     - b. Spacing.
     - c. Symbols.
     - d. Gage line.
     - e. Allowable loads.
  8. Welding.
     - a. Welding process.
     - b. Fillet.
     - c. Butt.
     - d. Strength and size.
     - e. Symbols.
  9. Standard connections.
     - a. Standard beam connections.
     - b. Seated connections.
     - c. Moment connections.
  10. Bevels—Inskip's or Smoley's Tables.
  11. Billing materials.
     - a. In notes.
     - b. In a bill of material.
  12. Fabricating operations.
     - a. Template making.
     - b. Laying out.
     - c. Punching.
     - d. Drilling.
     - e. Fitting and reaming.
     - f. Cutting, shearing, and sawing.
     - g. Straightening, bending, and rolling.
     - h. Milling.
     - i. Riveting.
     - j. Welding.
     - k. Painting.
- B. Laboratory: 53 hours.
  1. Make drawings of standard structural shapes where student has to fill in dimensions, using AISC *Manual of Steel Construction.*
  2. Detail steel beam with standard connection, with and without cope.
  3. Given a column schedule and framing plan, detail a steel column.
  4. Make a complete detail of a roof truss, including finding the slopes and lengths of the members, making layouts of the joints and determining the number of rivets required.
  5. Make a complete detail of a plate girder.
  6. Compute the strength and draw the symbols for various fillet and butt welds.
  7. Make a bill of materials.

III. Reinforced Concrete Drawing.
- A. Class: 12 hours.
  1. Drawing standards.
     - a. Sizes.
     - b. Scales.
     - c. Recommended layout for drawings.
     - d. Designations.
     - e. Symbols.
     - f. Abbreviations.
     - g. Lines.

2. Markings.
    - a. Parts of structure.
    - b. Bars.
3. Schedules.
    - a. Horizontal and vertical.
    - b. Information shown.
    - c. Typical bar bends.
4. Reinforcing bars.
    - a. Plain and deformed.
    - b. Welded wire fabric.
    - c. Spirals.
    - d. Standard sizes.
    - e. Weight.
    - f. Standard hooks.
    - g. Slant lengths.
    - h. Spacing.
    - i. Splices.
    - j. Ties.
    - k. Stirrups.
    - l. Dowels.
    - m. Fabrication tolerances.
5. Dimensioning.
    - a. Techniques.
    - b. Placing of dimensions.
    - c. Number, size, length, bending details, and spacing of bars.
    - d. Size and location of concrete members.
6. Types of reinforced concrete drawings.
    - a. Engineering.
    - b. Placing.
    - c. Combined engineering and placing.
7. Bar supports.
    - a. Specifications.
    - b. Standard nomenclature.
8. Composite construction.
9. Bar lists.

B. Laboratory: 45 hours.

1. Make a foundations and columns engineering drawing.
2. Make a foundations placing drawing.
3. Make an engineering drawing of two-way slab and beam floor.
4. Make a location drawing of beam and girder floor.
5. Make an engineering drawing of joint floor.
6. Make a placing drawing of flat slab floor.
7. Make a detail of composite floor construction.
8. Make some bar lists.

TEXTS AND REFERENCES

American Concrete Institute. *Manual of Standard Practice for Detailing Reinforced Concrete Structures*

American Institute of Steel Construction. *Manual of Steel Construction*

———. *Structural Shop Drafting*

Bishop. *Structural Drafting*

Concrete Reinforcing Steel Institute. *A Manual of Standard Practice for Reinforced Concrete Construction*

Crane. *Architectural Construction*

Giesecke, Mitchell, and Spencer. *Technical Drawing*

Hoelscher and Springer. *Engineering Drawing and Geometry*

Inskip. *Inskip's Tables*

Kenny and McGrail. *Architectural Drawing for the Building Trades*

Morgan. *Architectural Drawing*

Ramsey and Sleeper. *Architectural Graphic Standards*

Rising and Almfeldt. *Engineering Graphics*

Saylor. *Dictionary of Architecture*

Sleeper. *Architectural Specifications*

Smoley. *Tables; . . . For Engineers, Architects, and Students*

"Time-Saver Standards", *Architectural Records*

VISUAL AND TRAINING AIDS

Bethlehem Steel Co., Bethlehem Pa.
Men, Steel, and Earthquakes (fabricated steel). 28 min., 16 mm., color, sound
Steel in Concrete (reinforcing bars). 38 min., 16 mm., color, sound

Purdue Research Foundation, Lafayette, Ind.
Structural Drawing. 20 min., 16 mm., black and white, silent

U.S. Department of the Interior, Bureau of Mines, Washington, D.C., 20240
The Story of Arc Welding. 25 min., 16 mm., color, sound

United States Steel Corp., Public Relations Dept., 208 South La Salle St., Chicago, Ill.
Building for the Nations. 35 min., 16 mm., color, sound

APPLIED BUILDING CONSTRUCTION

HOURS REQUIRED

Class, 3; Laboratory, 3; Credit, 4.

Description

This course acquaints students with the terminology and materials used in building construction, types of construction used for the various parts of buildings, and items to be considered in planning a building.

Instruction Suggestions

It is recommended that this class meet for three 1-hour informal lecture-discussion periods and one 3-hour laboratory period a week. Frequent use should be made of movies, slides, drawings, flip charts, models, samples of materials, and manufacturers' catalogs. The student should spend an average of 3 hours a week in studying text assignments.

Part of the laboratory periods should be spent in making inspection trips to nearby buildings under construction or to plants making building materials if any are located in the vicinity. During some of the other laboratory periods, it is suggested that the students sketch various building construction details, figure quantities of building materials, and estimate costs of materials and construction. The laboratory time can also be used to supplement the informal lecture-discussion periods, where additional time is needed, and for viewing films, slides, etc.

It is also suggested that a notebook showing various types of construction or different building materials be required. The students could be expected to spend an average of 3 hours a week outside of class on such a project, with some of the laboratory time devoted to the project. Also, outside reading in magazines and books should be assigned.

This course should supplement the work in Structural Detailing and Design. Many of the details and materials of construction, such as standard structural shapes, riveted and welded connections, and types of trusses, have been omitted here because they are covered elsewhere. Although it is impossible to cover every detail of construction and all of the materials used in building construction in this course, the student should become familiar with the basic details of construction and with the more common building materials, and know where to find information about special construction details and materials. The divisions on lighting, heating and ventilating, and plumbing are included to show the student the necessity of considering these items in planning the layout of the building and the details of construction, but not to make him a designer of lighting, heating, ventilating, or plumbing systems.

The number of laboratory hours suggested for each division may be modified according to the instructor's individual plan for laboratory and field trip study of the subject. Details of what laboratory exercises are to be performed have not been provided. The instructor should use field trips and laboratory example studies to cover each division.

	Hours	
MAJOR DIVISIONS	*Class*	*Laboratory*
I. Introduction	2	0
II. General Considerations in Planning a Building	1	3
III. Lighting of Buildings	2	3
IV. Heating and Ventilating	3	3
V. Plumbing	2	3
VI. Footings and Foundations	4	3
VII. Masonry Construction	4	3
VIII. Wood Construction	4	3
IX. Steel Construction	4	3
X. Concrete Construction	4	3
XI. Floor Construction and Floor Surfaces	4	3
XII. Roof Construction and Roof Surfaces	4	3
XIII. Doors and Door Frames	2	3
XIV. Windows and Window Frames	2	3
XV. Stairs and Elevators	2	3
XVI. Cost Estimating	4	6
Total	48	48

I. Introduction.
  A. Class: 2 hours.
    1. General survey of building industry.
    2. Classification of building.
    3. Building codes.
  B. Laboratory: 0 hours.

II. General Considerations in Planning a Building.
  A. Class: 1 hour.
    1. Usage—present and future.
    2. Equipment required in building.
    3. Property cost.
    4. Character of foundation material.
    5. Availability of materials.
    6. Local codes.
    7. Labor supply and cost.
    8. Appearance.
    9. Environmental control.
    10. Safety considerations.
  B. Laboratory: 3 hours.

III. Lighting of Building.
  A. Class: 2 hours.
    1. Daylight in industrial buildings.
      a. Measure of illumination (foot-candle).
      b. Amount of illumination obtained through various types of windows.
      c. Effect of roof construction on illumination.
    2. Daylight in multistory buildings.
      a. Window sizes and arrangements.
      b. Floor heights.
      c. Shape of buildings.
      d. Reflection qualities of interior surfaces.
      e. Glass block.
      f. Structural considerations.
    3. Artificial lighting.
      a. Physiological considerations.
      b. Lighting systems.
      c. Computing intensity of light.
    4. Considerations in planning for conduits.
  B. Laboratory: 3 hours.
IV. Heating and Ventilating.
  A. Class: 3 hours.
    1. Heating.
      a. Direct system of radiation.
      b. Indirect system of radiation.
      c. Types of radiators.
      d. Special construction details for recessed radiators.
    2. Ventilating.
      a. Number of air changes required.
      b. Chimney action—convection currents in buildings.
      c. Effect of wind action.
      d. Aeration computations.
      e. Roof ventilators.
      f. Mechanical ventilation.
    3. Effect of pipes, ducts, and other heating and ventilating equipment on type, shape, and details of construction.
  B. Laboratory: 3 hours.
V. Plumbing.
  A. Class: 2 hours.
    1. Soil tests—need and type.
    2. Legal aspects of excavations.
    3. Footings—types and where used.
    4. Pile foundations.
    5. Concrete piers.
      a. Open-well methods.
      b. Caisson methods.
    6. Drainage of foundations.
    7. Waterproofing of foundations.
    8. Termite control.
  B. Laboratory: 3 hours.
VII. Masonry Construction.
  A. Class: 4 hours.
    1. Classes of walls.
    2. Parts of exterior masonry walls.
    3. Parts of masonry arch.
    4. Wall furring.
    5. Masonry.
      a. Brick.
      b. Stone.
      c. Hollow tile.
      d. Concrete.
      e. Concrete block.
      f. Architectural terra cotta.
  B. Laboratory: 3 hours.
VIII. Wood Construction.
  A. Class: 4 hours.
    1. Types of framing used in houses and other small buildings.
    2. Frame walls and partitions.
    3. Exterior surfaces.
    4. Fasteners used in wood framing.
      a. Nails.
      b. Screws.
      c. Bolts
      d. Dowels.
      e. Special fasteners.
    5. Ordinary construction.
      a. For dwellings.
      b. For light commercial buildings.
    6. Slow-burning or mill construction.
      a. Girder type.
      b. Beam and girder type.
      c. Laminated type.
  B. Laboratory: 3 hours.
IX. Steel Construction.
  A. Class: 4 hours.
    1. General framing schemes.
    2. Wind stresses.
    3. Earthquake stresses.
    4. Concrete subjected to shock.
    5. Expansion and contraction joints.
    6. Precast concrete.

7. Prestressed concrete.
8. Forms for concrete—wood and metal.
B. Laboratory: 3 hours.
X. Concrete Construction.
A. Class: 4 hours.
1. General framing schemes.
2. Wind stresses
3. Earthquake stresses.
4. Concrete subjected to shock.
5. Expansion and contraction joints.
6. Precast concrete.
7. Prestressed concrete.
8. Forms for concrete—Wood and metal
B. Laboratory: 3 hours.
XI. Floor Construction and Floor Surfaces.
A. Class: 4 hours.
1. Wood floors on wood joists.
2. Heavy-timber subfloors.
3. Concrete floors.
4. Steel floors.
5. Ground-floor construction.
a. Drainage.
b. Portland cement concrete base.
c. Bituminous concrete base.
d. Hollow clay-tile base
6. Considerations in selecting types of floors.
7. Types of floor surfaces.
8. Items to consider in selection of wearing surfaces.
B. Laboratory: 3 hours.
XII. Roof Construction and Roof Surfaces.
A. Class: 4 hours.
1. Types of roofs.
2. Types of dormers.
3. Types of roof decks.
4. Roofing materials.
5. Factors to consider in selection of roof covering.
6. Insulation of roof.
7. Roof drainage.
B. Laboratory: 3 hours.
XIII. Doors and Door Frames.
A. Class: 2 hours.
1. Parts of doors and door frames.
2. Types of operations.
3. Types of doors.
a. Wood.
b. Hollow metal and metal covered.
c. Tin-clad, sheet-steel, corrugated-steel, and steel rolling doors.
B. Laboratory: 3 hours.
XIV. Windows and Window Frames.
A. Class: 2 hours.
1. Parts of windows and window frames.
2. Sash types.
3. Materials.
a. Wood.
b. Solid-section metal windows.
c. Hollow metal and metal covered windows.
4. Glass and glazing.
a. Classification of glass for glazing purposes.
b. Thickness, sizes and grades.
c. Glazing.
B. Laboratory: 3 hours.
XV. Stairs and Elevators.
A. Class: 2 hours.
1. Definitions of stair parts.
2. Proportioning of stairs.
3. Special treads.
4. Railings.
5. Stair materials.
a. Wood.
b. Concrete.
c. Steel and cast iron.
d. Stone and brick.
6. Electric stairways.
7. Elevators.
B. Laboratory: 3 hours.
XVI. Cost Estimating.
A. Class: 4 hours.
1. Approximate estimates.
2. Detailed estimates.
B. Laboratory: 6 hours.

TEXTS AND REFERENCES

Bateman. *Materials of Construction*
Cooper. *Building Construction Estimating*
Crane. *Architectural Construction*
Crocker. *Piping Handbook*
Dallavia. *Estimating General Construction Costs*
Demarest. *U.S. Directory of Modular Building Materials*
Downs. *Applied Science of Estimating*
Dunham. *Planning Industrial Structures*
Huntington. *Building Construction*
International Correspondence Schools. *Building Trades Handbook*
Kay. *The Modern Building Encyclopedia*
Kent. *Mechanical Engineers' Handbook*
Marks. *Mechanical Engineers' Handbook*
Merritt. *Building Construction Handbook*
Page. *Estimator's General Construction Man-Hour Manual*
Peurifoy. *Estimating Construction Costs*

Plum. *Plumbing Practice and Design*
Ramsey and Sleeper. *Architectural Graphic Standards*
Saylor. *Dictionary of Architecture*
Sleeper. *Architectural Specifications*
Steinberg and Stempel. *Practices and Methods of Construction*
Sweet's Catalog Service Division. *Architectural File*
"Time-Saver Standards", *Architectural Record*
Urquhart. *Civil Engineering Handbook*
Withey and Washa. *Materials of Construction*

VISUAL AND TRAINING AIDS

American Institute of Architects, Washington, D.C.
Architecture-U.S.A. 26 min., 16 mm., color, sound
Bethlehem Steel Co., Bethlehem, Pa.
Fury of the Winds (fabricated steel and the Atlantic hurricane). 16 mm., color, sound
Men, Steel and Earthquakes (fabricated steel). 28 min., 16 mm., color, sound
Skylines (structural steel). 29 min., 16 mm., color, sound
Portland Cement Association, 33 West Grant Ave., Chicago, Ill.
Build With Concrete Masonary. 15 min., 16 mm., color, sound
United States Steel Corp., Public Relations Dept., 208 South La Salle Street, Chicago, Ill.
Building for the Nations. 35 min., 16 mm., color, sound
Modern Steelmaking. 23 min., 16 mm., color, sound.
United World Films, Inc., 1445 Park Ave., New York, N.Y.
Building Techniques: Foundations and Concrete. 26 min., 16 mm., black and white
Building Techniques: Framing: Floor Joists and Walls. 30 min., 16 mm., black and white, sound
Building Techniques: Framing: Rafter Principles and Common Rafters. 15 min., 16 mm., black and white, sound
Manufacturers' catalogs and manuals
Samples of building materials
Typical building plans
Local building codes

ESTIMATING AND OFFICE PRACTICES

Hours Required

Class, 3; Laboratory, 4; Credit, 4.

Description

An introduction to estimating and construction office practice to familiarize the student with the construction process as a whole, the ways in which contractors organize their offices to accomplish a job of construction, the generation of plans and specifications and their use, systems of accounting, and how material quantity "take-off" forms the basis for accounting. Critical-path method of planning and scheduling is studied intensively to teach this increasingly important technique.

Instruction Suggestions

It is recommended that this class meet for three 1-hour lecture periods and two 2-hour laboratory sessions a week. Close compatibility should be maintained between the subject matter presented in lectures and the problem-solving exercises given in the laboratory session. Problem emphasis should be on the logical processing of information required in estimating, bidding, scheduling, purchasing, and cost control.

In the computer programing section, in particular, the instruction should be limited to the use of the FORTRAN source language and the computer problems should be of the data processing type, utilizing the information given in the other major subject areas as problem source material.

	Hours	
Major Divisions	*Class*	*Laboratory*
I. Construction Process and Contractor Organization	2	4
II. Plans and Specifications	4	4
III. Cost and Accounting Systems	4	4
IV. Quantity "Take-Off"	5	8
V. Critical Path Method Planning and Scheduling	9	12
VI. Contractor's Estimate Preparation	3	4
VII. Purchasing and Expediting	3	4
VIII. Cost Reporting and Control	3	4
IX. Payment Estimates and Special Reports	3	4
X. Computer Programing	12	16
Total	48	64

I. Construction Process and Contractor Organization.
  A. Class: 2 hours.
    1. Function of and interrelationships between the owner, architectural and/or engineering group, and contractor.
    2. Typical contractor organizational structures and their variation with size and ownership form; function of various groups and departments within organization.
  B. Laboratory: 4 hours.
    1. Study and solve a problem in identifying owner - architect - contractor functions.
    2. Study and solve a problem in identifying department function within a contracting organization.

II. Plans and Specifications.
  A. Class: 4 hours.
    1. Purposes of specifications.
    2. Typical specification divisions.
    3. Variation of specifications for different types of work—buildings, highway, engineering projects, and industrial.
    4. Standardized specifications.
    5. Modular design objectives.
  B. Laboratory: 4 hours.
    Examine and study typical plans and specifications for a building, highway, heavy engineering project, and an industrial process job.

III. Cost Accounting Systems.
  A. Class: 4 hours.
    1. Principles of double-entry general accounting.
    2. Principles of cost accounting.
    3. Origin, purpose, and intraorganizazational flow of cost figures.
    4. Office and field reporting forms.
    5. Bid items—contractor defined and award agency defined.
  B. Laboratory: 4 hours.
    1. Study and solve problems of entries within general and cost accounting systems.
    2. Study and solve a trial-balance problem.
    3. Study and solve a problem in use of typical reporting forms.
    4. Study and solve a problem in definition of bid items.

IV. Quantity "Take-Off".
  A. Class: 5 hours.
    1. Form and order of quantity survey.
    2. Breakdown according to crafts and bid items.
    3. Addenda.
    4. Effect of proposal alternates on take-off.
    5. Order of take-off to achieve a multiple number of quantities in one cycle.
    6. Computational procedures to limit round-off error.
    7. Multiplication of "feet and inch" dimensions.
    8. Variation of take-off with work classifications.
  B. Laboratory: 8 hours.
    Study and solve a problem in quantity take-off involving addenda, and alternates in contractor proposal.

V. Critical-Path Method Planning and Scheduling.
  A. Class: 9 hours.
    1. Network representation of construction projects.
    2. Time calculations on the network.
    3. Computer applications.
    4. Resource allocation and network analysis.
  B. Laboratory: 12 hours.
    1. Study and solve a problem in network logic.
    2. Study and solve a problem of deriving a network and schedule from a project description (plans, specifications, and resources availability).

VI. Contractor's Estimate Preparation.
  A. Class: 3 hours.
    1. Subcontractor proposal analysis.
    2. Collection sheets and form of estimate.
    3. Pricing unit costs in proposal.
    4. Overhead estimate.
  B. Laboratory: 4 hours.
    Study a problem in estimate preparation, using project of Sections IV and V including analysis of subcontractor's proposals.

VII. Purchasing and Expediting.
  A. Class: 3 hours.
    1. Purchase orders and their execution.
    2. Award of contracts to subcontractors.
    3. Timing of material deliveries and subcontracted work to conform with schedule.
    4. Procedures followed in expediting and tracing of freight shipments.
    5. Checking and approval of shop drawings.
  B. Laboratory: 4 hours.
    1. Study and solve a problem in generating a schedule of material deliveries and subcontractor starts.
    2. Solve a problem in checking shop drawings.

VIII. Cost Reporting and Control.
- A. Class: 3 hours.
  1. Cost reporting on labor, material, overhead, and equipment.
  2. Forms for field reporting.
  3. Allocation of costs to accounts.
  4. Cost control.
- B. Laboratory: 4 hours.
  Prepare and solve a problem in preparation and processing field and office cost reports.

IX. Payment Estimates and Special Reports.
- A. Class: 3 hours.
  1. Breakdown of proposal for payment estimates.
  2. Pay estimates with unit price contracts.
  3. Preparation and submission of payment estimates.
  4. Cost versus income predictions and reports.
  5. Change orders.
- B. Laboratory: 4 hours.
  1. Prepare and solve a problem in payment estimate preparation given required field information.
  2. Prepare and solve a problem in cost versus income report.

X. Computer Programing.
- A. Class: 12 hours.
  1. Organization of digital computers.
  2. FORTRAN system.
  3. Constants, variables, and subscripts.
  4. Arithmetic statements and expressions.
  5. Control statements including looping.
  6. Input/output control.
  7. Subroutines, functions, and subprograms.
- B. Laboratory: 16 hours.
  1. Prepare and analyze an arithmetic operation oriented program (quantity take-off).
  2. Study a problem involving looping (quantity take-off continued or CPM program).
  3. Perform and analyze data processing exercise (cost reporting).
  4. Prepare an inventory control program (purchasing).

TEXTS AND REFERENCES

Clough. *Construction Contracting*
Dallavia. *Estimating General Construction Costs*
Deatherage. *Construction Company Organization and Management*
Foster. *Construction Estimates from Take-Off to Bid*
Miller. *Successful Management for Contractors*
O'Brien. *CPM in Construction Management-Scheduling by the Critical-Path Method*
Peurifoy. *Construction Planning, Equipment, and Methods*
Pulver. *Construction Estimates and Costs*
Shaffer, Ritter, and Meyer. *The Critical-Path Method*

STRUCTURAL DETAILING AND DESIGN

HOURS REQUIRED

Class, 3; Laboratory, 3; Credit, 4.

Description

This course is an introduction to elementary structural analysis and design. Emphasis is placed on the analysis and design of simple members of statically determinate steel structures, with some work on timber design.

Instruction Suggestions

It is suggested that this class meet for three 2-hour periods a week. The first hour or less should be an informal lecture-discussion of the material for that day. The remainder of the class period should be devoted to working problems involving the analysis or design of structural members. Some design problems will run for more than one period and may even be made part of the homework problems. The student should become familiar with basic analysis and design procedures, specifications and building codes, and proper use of handbooks where applicable. The economic aspects of design should be considered along with those of structural strength.

MAJOR DIVISIONS	Hours Class	Hours Laboratory
I. Introduction	1	1
II. External Forces—Loads	2	2
III. Reactions, Shear and Bending Moment	7	7
IV. Trusses	4	4
V. Design of Rolled-Steel Structural Beams	4	4
VI. Design of Steel Plate Girder	6	6
VII. Design of Steel Tension Members	4	4
VIII. Design of Steel Compression Members	8	8
IX. Design of Connections	4	4
X. Design of Timber Members	8	8
Total	48	48

- I. Introduction.
    - A. Class: 1 hour.
        - 1. Functional design.
        - 2. Structural design.
        - 3. Types of structures and structural framing.
    - B. Laboratory: 1 hour.
      Solve a problem in identifying types of structures and structural framing.
- II. External Forces—Loads.
    - A. Class: 2 hours.
        - 1. Weight of construction.
        - 2. Weight of trusses.
        - 3. Floor loads—buildings.
        - 4. Roof loads.
        - 5. Wind loads.
        - 6. Impact.
        - 7. Earthquake shock.
        - 8. Lateral pressure.
    - B. Laboratory: 2 hours.
        - 1. Compute loads on floors and on trusses.
        - 2. Estimate the weight of a truss by formula, and calculate the panel loads for dead load and snow.
        - 3. Calculate wind pressures on a structure.
- III. Reactions, Shear and Bending Moment.
    - A. Class: 7 hours.
        - 1. Character of reactions.
            - a. Simple.
            - b. Hinged.
            - c. Restrained.
        - 2. Determination of reactions.
            - a. From fixed loads.
            - b. From live loads.
        - 3. Shear and moment diagrams (review).
        - 4. Influence lines.
            - a. For shear.
            - b. For moment.
            - c. For reactions.
    - B. Laboratory: 7 hours.
        - 1. Determine reactions of various structures.
        - 2. Draw shear and moment diagrams of various members and structures.
        - 3. Draw influence lines for reactions, shear, and moment.
- IV. Trusses.
    - A. Class: 4 hours.
        - 1. Primary and secondary stress.
        - 2. Joint loads.
        - 3. Reactions.
        - 4. Stresses in members.
            - a. Analytical method.
            - b. Graphical method.
            - c. Live load, dead load, and combined stresses.
        - 5. Deflection.
    - B. Laboratory: 4 hours.
        - 1. Compute loads on a truss and find stresses in members graphically for both fixed and moving loads.
        - 2. Compute deflection of a truss.
- V. Design of Rolled-Steel Structural Beams.
    - A. Class: 4 hours.
        - 1. Selection by section modulus.
        - 2. Safe load tables.
            - a. Beams with lateral support.
            - b. Beams without lateral support.
        - 3. Web strength.
            - a. Shear.
            - b. Crippling of web.
        - 4. Deflection.
            - a. Lateral.
            - b. Vertical.
    - B. Laboratory: 4 hours.
        - 1. Design a laterally supported beam with uniform or concentrated loads or both. Use safe load tables and section modulus methods.
        - 2. Design beams which are not laterally supported.
- VI. Design of Steel Plate Girder.
    - A. Class: 6 hours.
        - 1. Design assumptions.
        - 2. Design of web.
        - 3. Design of flange.
            - a. Net section.
            - b. Cover plates.
                - (1) Size.
                - (2) Length.
        - 4. Web stiffeners.
            - a. Bearing stiffeners.
            - b. Intermediate stiffeners.
            - c. Filler plates.
            - d. Crimped stiffeners.
            - e. Spacing.
        - 5. Pitch of rivets.

6. Splices.
    a. Web.
    b. Flange.

B. Laboratory: 6 hours.
1. Design a plate girder with stiffeners and cover plates.
2. Design a splice for a plate girder.

VII. Design of Steel Tension Members.

A. Class: 4 hours.
1. Net section.
2. Proportioning members.
3. Single-plane type.
4. Double-plane type.
5. Members subject to direct tension and bending.

B. Laboratory: 4 hours.
1. Design single-plane-type tension members of a roof truss.
2. Design double-plane-type tension members.

VIII. Design of Steel Compression Members.

A. Class: 8 hours.
1. Axially loaded columns.
    a. Slenderness ratio.
    b. Short, intermediate, and long columns.
2. Column formulae.
    a. Euler.
    b. AISC specifications.
3. Selection and design of columns.
    a. Types of column sections.
    b. Shear in builtup columns.
    c. Safe load tables.
4. Eccentric loads—bending and direct stress.

B. Laboratory: 8 hours.
1. Design a column for a building.
2. Design single-plane-type compression members of a roof truss.
3. Design double-plane-type compression members.
4. Design member subject to bending and direct stress.

IX. Design of Connections.

A. Class: 4 hours.
1. Riveted and bolted connections.
2. Eccentric loads on rivet groups.
3. Pins.
4. Welded connections.
5. Eccentric loads on weld groups.

B. Laboratory: 4 hours.
1. Calculate number of rivets needed in truss joint.
2. Analyze eccentric rivet and weld groups.
3. Calculate the amount of weld needed for various connections.

X. Design of Timber Members.

A. Class: 8 hours.
1. Grades and sizes of timber.
2. Working stresses for structural timbers.
    a. Defects.
    b. Exposure.
3. Special devices for connecting timbers.
4. Wood beams and joists.
    a. Stress on extreme fiber due to flexure.
    b. Horizontal shear stress.
    c. Stress in compression across the grain at end bearings and under concentrated loads.
    d. Deflection.
5. Built up beams and girders.
    a. Laminated beams.
    b. Keyed beams.
6. Trussed beams.
7. Axial loaded columns.
    a. Slenderness ratio.
    b. Short, intermediate, and long columns.
    c. Design formulae.
8. Columns with combined bending and direct stress.
9. Tension members.
10. Trusses.

B. Laboratory: 8 hours.
1. Design a beam to carry a given load and calculate length of bearings of end.
2. Design a column to carry a given axial load.
3. Design parts of a small timber truss including connections.

TEXTS AND REFERENCES

American Institute of Steel Construction. *Manual of Steel Construction.*
Cissel. *Stress Analysis and Design of Elementary Structures*
Gaylord and Gaylord. *Design of Steel Structures*
Grinter. *Design of Modern Steel Structures*

Halperin. *Building With Steel*

National Lumber Manufacturers Association. *National Design Specifications for Stress-Grade Lumber and Its Fastenings*

———. *Wood Structural Design Data*

Shedd. *Structural Design in Steel*

——— and Vawter. *Theory of Simple Structures*

Southern Pine Association. *Modern Timber Engineering*

Timber Engineering Company. *Designing Timber Connector Structures*

———. *Timber Design and Construction Handbook*

U.S. Department of Agriculture. *Wood Handbook*

Winter, Urquhart, O'Rourke, and Nilson. *Design of Concrete Structures*

MATHEMATICS AND SCIENCE COURSES

TECHNICAL MATHEMATICS I

Hours Required

Class, 5; Laboratory, 0; Credit, 5.

Description

First course in a two-semester sequence of integrated mathematics covering selected topics in algebra, trigonometry, analytical geometry, and calculus.

Instruction Suggestions

The courses in Technical Mathematics are designed for close integration with those in Technical Physics, Mechanics, and Surveying. Owing to differences in individual situations, it will be necessary for the staff to examine the course content in these areas periodically so that this integration of material is maintained. In order to cover the material adequately, supplementary texts or notes may be needed. It may also be advantageous to increase the number of contact hours with classes in supervised problem-solving.

Major Divisions		*Class hours*
I.	Numerical Computations and Basic Slide Rule	5
II.	Introduction to Trigonometry	8
III.	Algebraic Operations	7
IV.	Equations	15
V.	Exponents and Radicals	10
VI.	Quadratic Equations	5
VII.	Ratio and Proportion	3
VIII.	Simultaneous Equations	7
IX.	Logarithms	10
X.	Continuation of Trigonometry	10
	Total	80

I. Numerical Computations and Basic Slide Rule.

Class: 5 hours.

1. The system of real numbers.
2. Rational and irrational numbers.
3. Operations with zero.
4. Fractions, exponents.
5. Computation with numbers of limited accuracy.
6. Probability and statistical accuracy.
7. Slide rule—multiplication and division.

II. Introduction to Trigonometry

Class: 8 hours.

1. Relation between degree and radian measurement.
2. Definition of trig functions (acute angle).
3. Tables of trig functions, and interpolation of tables.
4. Solution of right triangles.
5. Slide rule—trig scales.

III. Algebraic Operations

Class: 7 hours.

1. Associative, distributive, commutative laws.
2. Addition and subtraction.
3. Multiplication and division.
4. Factoring.

IV. Equations.

Class: 15 hours.

1. The meaning of an equation.
2. Solving one equation in one unknown.
3. Formula rearrangement and evaluation.

V. Exponents and Radicals.

Class: 10 hours.

1. The laws of exponents.
2. Integer exponents.
3. Fractional exponents.
4. Relation between fractional exponents and radicals.
5. The complex number and its meaning.

VI. Quadratic Equations.

Class: 5 hours.

1. Completing the square.
2. Factoring.

VII. Ratio and Proportion.

Class: 3 hours.

1. Direct proportion.
2. Inverse proportion.

VIII. Simultaneous Equations.

Class: 7 hours.

1. Linear equations in two unknowns.
2. Three unknowns.
3. Solution by elimination.
4. Solution by determinants.

IX. Logarithms.
   Class: 10 hours.
   1. Relation between logs and exponents.
   2. Operations with logs.
   3. Base 10 logs, base e logs.
   4. Tables.
   5. The construction and operation of the slide rule.

X. Continuation of Trigonometry.
   Class: 10 hours.
   1. Review of right triangles.
   2. Extension of functions for angles greater than 90°.
   3. The concept of polar coordinates.
   4. Graphs of the six functions.
   5. Sums and differences of curves.
   6. Generation by rotation.

TEXTS AND REFERENCES

Andres, Miser, and Reingold. *Basic Mathematics for Science and Engineering*
Jaeger and Bacon. *Introductory College Mathematics*
Juszli and Rodgers. *Elementary Technical Mathematics*
Rice and Knight. *Technical Mathematics with Calculus*

TECHNICAL MATHEMATICS II

Hours Required
Class, 5; Laboratory, 0; Credit, 5.

Description

Second course in a two-semester sequence of integrated mathematics covering selected topics in algebra, trigonometry, analytical geometry, and calculus.

Instruction Suggestions

The courses in Technical Mathematics are designed for close integration with those in Technical Physics, Mechanics, and Surveying. Owing to differences in individual situations, it will be necessary for the staff to examine the course content in these areas periodically so that this integration of material is maintained. In order to cover the material adequately, supplementary texts or notes may be needed. It may also be advantageous to increase the number of contact hours with classes in supervised problem solving.

Major Divisions	*Class hours*
I. The Relation of Trig Functions	10
II. Solution of Oblique Triangles	10
III. Vectors	8
IV. Some Geometric Considerations	10
V. Differential Calculus	22
VI. Integral Calculus	20
Total	80

I. Relation of Trig Functions.
   Class: 10 hours.
   1. Trig functions for any angle.
   2. Identities.
   3. Phase shift.
   4. Half and double angle formulas.

II. Solution of Oblique Triangles.
   Class: 10 hours.
   1. Reduction to right angles.
   2. Sine law.
   3. Cosine law.
   4. Law of tangents.

III. Vectors.
   Class: 8 hours.
   1. Vectors and scalars.
   2. Addition and subtraction.
   3. Components of a vector.

IV. Some Geometric Considerations.
   Class: 10 hours.
   1. Equation of a straight line.
   2. Intersecting lines, parallel lines, distance between points.
   3. Circles.
   4. Conics—parabolas, ellipses, hyperbolas.

V. Differential Calculus.
   Class: 22 hours.
   1. Limit concept.
   2. Delta notation and definition of the derivative.
   3. Average and instantaneous rate of change.
   4. Derivatives of polynomials.
   5. Derivatives of products and quotients.
   6. Derivative of a function of a function.
   7. Derivatives of trig functions.
   8. Exponential and log functions.
   9. Maxima and minima.

VI. Integral Calculus.
   Class: 20 hours.
   1. Concept of summation.
   2. Approximate computation of an area.

3. Integration as an inverse of differentiation.
4. Integration of polynomials, trig functions, and logs and exponents.
5. Definite integral.
6. Applications to moment of inertia, areas, etc.

TEXTS AND REFERENCES

Andres, Miser, and Reingold. *Basic Mathematics for Science and Engineering*
Jaeger and Bacon. *Introductory College Mathematics*
Juszli and Rodgers. *Elementary Technical Mathematics*
Rice and Knight. *Technical Mathematics with Calculus*

TECHNICAL PHYSICS I
(Mechanics)

Hours Required

Class, 3; Laboratory, 2; Credit, 3.

Description

Course in the basic principles of mechanics applied to solid particles and to fluids. It gives the student an introduction to the scientific method.

Instruction Suggestions

It is suggested that the course consist of 1 hour of lecture, 2 hours of quiz and recitation, and a 2-hour laboratory period each week. The instructor should maintain liaison with the mathematics instructor since the rate of progress in this course will depend upon topic coverage in technical Mathematics I. Emphasis should be placed on having the students solve many carefully selected problems.

	Hours	
Major Divisions	*Class*	*Laboratory*
I. Fundamental Quantities	6	2
II. Vectors	6	4
III. Uniform Motion	3	2
IV. Accelerated Motion	5	4
V. Force	6	6
VI. Rotational Motion	4	2
VII. Statistics	9	8
VIII. Liquids at Rest	5	2
IX. Liquids in Motion	4	2
Total	48	32

I. Fundamental Quantities.
  A. Class: 6 hours.
    1. Length, mass, time.
    2. Measurement and standards, accuracy and precision.
  B. Laboratory: 2 hours.
    1. Use vernier and micrometer measuring devices.
    2. Study and illustrate variability in measurement.
II. Vectors.
  A. Class: 6 hours.
    1. Characteristics of vectors.
    2. Vector addition and subtraction.
    3. Triangles.
    4. Resolution of vectors.
    5. Moment of vectors.
  B. Laboratory: 4 hours.
    1. Determine the equilibrant of a system of concurrent forces and convert to a vector diagram.
    2. Confirm the equivalence of various vectors (displacements or forces).
III. Uniform Motion.
  A. Class: 3 hours.
    1. Linear motion.
    2. Speed and velocity.
    3. Angular motion.
    4. Relative motion.
  B. Laboratory: 2 hours.
    1. Measure rectilinear motion.
    2. Measure angular motion.
IV. Accelerated Motion.
  A. Class: 5 hours.
    1. Definition.
    2. Uniform acceleration.
    3. Projectile trajectories.
    4. Angular acceleration.
  B. Laboratory: 4 hours.
    1. Measure the motion of a free fall object.
    2. Compare trajectories of bodies in a constant gravity field.
V. Force.
  A. Class: 6 hours.
    1. Effect of force on motion.
    2. Newton's laws.
  B. Laboratory: 6 hours.
    1. Determine the coefficient of friction between various objects.
    2. Verify that frictional force is independent of the area of contact.
    3. Confirm the effects of mass and inertia.
    4. Measure how acceleration changes with increasing mass.

5. Measure how acceleration changes with increasing force.

VI. Rotational Motion.
A. Class: 4 hours.
1. Moment of inertia.
2. Angular motion.
B. Laboratory: 2 hours.
Measure the effect of rotational inertia on angular acceleration.

VII. Statics.
A. Class: 9 hours.
1. Equilibrium.
2. Resultants.
3. Free-body diagrams.
B. Laboratory: 8 hours.
1. Confirm the first and second conditions of equilibrium.
2. Confirm graphical solutions of crane problems.
3. Measure reactions at supports of parallel forces.
4. Calculate forces and moments in a structure.

VIII. Liquids at Rest.
A. Class: 5 hours.
1. Definitions.
2. Pascal's principle.
3. Archimedes' principle.
4. Surface tension.
B. Laboratory: 2 hours.
1. Confirm Pascal's principle.
2. Measure surface tension.

IX. Liquids in Motion.
A. Class: 4 hours.
1. Pumps.
2. Bernoulli's theorem.
3. Viscosity.
B. Laboratory: 2 hours.
Confirm Bernoulli's principle.

TEXTS AND REFERENCES

Blackwood and Kelley. *General Physics*
Chase and others. *Experiments in Nuclear Science*
Harris and Hemmerling. *Introductory Applied Physics*
Hausmann and Slack. *Physics*
Sears and Zemansky. *College Physics*, Part 1
Weber, White, and Manning. *Physics for Science and Engineering*
White. *Modern College Physics*

TECHNICAL PHYSICS II

Hours Required

Class, 3; Laboratory, 2; Credit, 3.

Description

Course in the basic principles of heat, sound, light, electricity, and magnetism, correlated with Technical Mathematics II.

Instruction Suggestions

It is suggested that the course consist of 1 hour of lecture, 2 hours of quiz and recitation, and a 2-hour laboratory period each week. Emphasis should be placed upon having the students solve many carefully selected problems.

	Hours	
Major Divisions	*Class*	*Laboratory*
I. Light	10	6
II. Sound	6	4
III. Heat and Temperature	6	4
IV. Thermodynamics	6	2
V. Electricity and Magnetism	20	16
Total	48	32

I. Light.
A. Class: 10 hours.
1. Properties of light.
2. Refraction and dispersion.
3. Lenses.
4. Optical instruments.
B. Laboratory: 6 hours.
1. Determine the nature of reflection and test the refraction of light.
2. Determine the focal length of a simple lens and study the effects of various positive and negative lens combinations.
3. Check the inverse square law for light from a point source and determine the luminous intensity of an unknown lamp.

II. Sound.
A. Class: 6 hours.
1. Vibrations and wave motion.
2. Characteristics of sound.
3. Transmission and reception.
4. Sound level and intensity.
B. Laboratory: 4 hours.
1. Determine the characteristics of standing waves in a string.
2. Determine the characteristics of a resonant air column.

        3. Examine thresholds of audibility and feeling for various frequencies of sound.
- III. Heat and Temperature.
    - A. Class: 6 hours.
        1. Heat.
        2. Temperature.
        3. Heat transfer.
    - B. Laboratory: 4 hours.
        1. Determine the mechanical equivalent of heat.
        2. Measure specific heat of various materials.
        3. Determine the coefficient of thermal expansion of various materials.
- IV. Thermodynamics.
    - A. Class: 6 hours.
        1. Gas laws.
        2. First law of thermodynamics.
        3. Second law of thermodynamics.
    - B. Laboratory: 2 hours.
        Confirm Boyle's law.
- V. Electricity and Magnetism.
    - A. Class: 20 hours.
        1. Electric charges.
        2. Magnetism.
        3. Resistance circuits, series and parallel.
        4. Capacitance.
        5. Inductance.
        6. Electromagnetism.
        7. Generators.
        8. Motors.
        9. Transformers.
    - B. Laboratory: 16 hours.
        1. Examine the effect of a magnet upon a wire carrying an electric current and sketch magnetic fields, using iron filings and various magnets.
        2. Measure unknown resistors with a Wheatstone Bridge.
        3. Measure unknown capacitors and unknown inductances; measure known capacitors and inductances in series and in parallel.
        4. Study voltage, current, and power in series and parallel resistive circuits.
        5. Measure voltage and current relationships in alternating current series circuits.
        6. Measure voltage and current relationships in alternating current parallel circuits.
        7. Study speed and torque characteristics of d.c. motors.
        8. Study single-phase transformers.

TEXTS AND REFERENCES

Blackwood and Kelley. *General Physics*
Harris and Hemmerling. *Introductory Applied Physics*
Hausmann and Slack. *Physics*
Ridenour and Nierenberg. *Modern Physics for the Engineer.*
Sears and Zemansky. *College Physics*, Part I
Shortley and Williams. *Elements of Physics for Students of Science and Engineering*
Weber, White, and Manning. *Physics for Science and Engineering.*
White. *Modern College Physics*

MECHANICS

(Statics and Dynamics)

Hours Required

Class, 3; Laboratory, 0; Credit, 3.

Description

This course introduces the basic concepts of mechanics, placing emphasis on the action of force systems on rigid bodies and the response of those bodies to the applied forces. The first portion of the semester is devoted to the study of statics, or stationary bodies, while the second portion is devoted to dynamics, or bodies in motion.

Instruction Suggestions

The instructor should collaborate with the mathematics instructor since the concept of rate of change of a quantity will be introduced in both this and the mathematics courses at about the same time. Further, the instructor should emphasize the basic principles of Newtonian mechanics, rather than specialized equations, throughout the course. If more time is required for a division of material such as III, it is suggested that division VII might be deleted. The deleting of division IX in order to give more thorough coverage to other items is also a possibility. Emphasis should be placed on having the students solve many carefully selected problems.

Major Divisions	Class hours
I. General Concepts	3
II. Simple Force Systems	6
III. Noncurrent Forces in a Plane	8
IV. Friction	3
V. Rectilinear Motion	5
VI. Angular Motion	3
VII. Simple Harmonic Motion	2
VIII. Equations of Motion	9
IX. Impulse and Momentum	4
X. Work and Energy	5
Total	48

I. General Concepts.
  Class: 3 hours.
  1. Characteristics of forces.
  2. Force systems.
  3. Moment of force.
  4. Couples.
  5. Center of gravity.
  6. Moment of inertia.
  7. Radius of gyration.

II. Simple Force Systems.
  Class: 6 hours.
  1. Vector quantities.
  2. Resolution of forces
  3. Free-body diagrams.

III. Nonconcurrent Forces in a Plane.
  Class: 8 hours.
  1. Parallel forces.
  2. Nonparallel forces.
  3. Levers.
  4. Applications, frames and trusses.

IV. Friction.
  Class: 3 hours.
  1. Static and kinetic friction.
  2. Angle of repose.
  3. Applications.

V. Rectilinear Motion.
  Class: 5 hours.
  1. Speed and velocity.
  2. Acceleration.
  3. Relative motion.

VI. Angular Motion.
  Class: 3 hours.
  1. Uniform angular motion.
  2. Angular and linear acceleration.

VII. Simple Harmonic Motion.
  Class: 2 hours.

VIII. Equations of Motion.
  Class: 9 hours.
  1. Force systems.
  2. Inertia and mass.
  3. Newton's laws.
  4. Plane motion of a rigid body.

IX. Impulse and Momentum.
  Class: 4 hours.
  1. Linear momentum.
  2. Angular momentum.

X. Work and Energy.
  Class: 5 hours.
  1. Work.
  2. Conservation of energy.
  3. Potential energy.
  4. Kinetic energy.
  5. Principle of work and energy.

TEXTS AND REFERENCES

Bassin and Brodsky. *Statics and Strength of Materials*
Breneman. *Mechanics*
Jensen. *Applied Engineering Mechanics*
———. *Statics and Strength of Materials*
Key. *Elementary Engineering Mechanics*
Levinson. *Introduction to Mechanics*

AUXILIARY OR SUPPORTING TECHNICAL COURSES

HIGHWAY AND STRUCTURAL TECHNOLOGY SEMINAR

Hours Required

Class, 1; Laboratory, 0; Credit, 0.

Description

The course begins with a brief orientation to the school. A general review of technical occupations follows, with a study of the work life of technical personnel, the part that interests, aptitudes, and ethical attitudes play in the successful attainment of technical employment goals, and the program of study required of technicians. Field trips give the student the opportunity to see the civil engineering technician in action, and individual interviews give the instructor firsthand information about the student.

Instruction Suggestions

Movies or other training aids could be used to supplement or replace field trips if these are not feasible. Guest lecturers from State or municipal highway department offices and outstanding engineers, architects, and contractors should be invited to take part in the program. These men would provide the student with valuable future contacts and would give him the employer's attitudes toward the technician and his place in the industry. It is recommended that the student submit reports on all field trips.

Major Divisions	Class hours
I. The School	2
II. Technical Personnel	6
III. The Program of Study	2
IV. Field Trips	5
V. Individual Counseling	1
Total	16

I. The School.

Class: 2 hours.

1. Purpose of orientation.
2. The technical institute, its place in education, the associate degree, accreditation.
3. How and when to study.
4. What counseling is, where it is obtained.
5. Scholarship and assistance programs.

II. Technical Personnel.

Class: 6 hours.

1. The world of work.
    - a. Occupational levels and preparation.
    - b. Qualifications for typical occupations.
    - c. Professional practice.
2. Aptitudes required in civil technology in both highway and structural construction options.
3. Assessing personal aptitudes—guidance and testing.
4. Nature of technician work.
    - a. The engineering team.
    - b. Typical work of the technician.
    - c. Agencies, both private and public, employing technicians.
5. Job opportunities.
    - a. Wages.
    - b. Promotional possibilities.
    - c. Local employment possibilities in civil technology.
    - d. Further schooling.
6. Employment practices.
    - a. Recruitment.
    - b. Tests.
    - c. Interviews.
    - d. School placement department.
7. Ethics.
    - a. The technician's attitude toward his work.
    - b. The technician's attitude toward his fellow workers.
    - c. The technician's attitude toward his employer.
    - d. Importance of accuracy, completeness, and honesty in records, notes, and reports.

III. The Program of Study.

Class: 2 hours.

1. Purpose of courses.
    - a. General education.

   b. Related subjects.
   c. Technical subjects.
2. Arrangement of the curriculum.
   a. Highway option.
   b. Structural option.
3. The grading system and tests.
4. Opportunities in noninstitute courses.
5. Extracurricular activities.
6. Curriculum planning sheet—a guide to each semester's program.

IV. Field Trips.

Class: 5 hours.

1. Preparation for trips to nearby highway and building construction jobs; what to look for, type of questions to be asked of engineers and contractors.
2. Tours planned specifically to show the technician at work.
3. Discussion of trips, conclusions that may be drawn.
4. Reports to be prepared and submitted for each field trip made.

V. Individual Counseling.

Class: 1 hour.

1. Establish rapport with each student, discuss individual's objectives, aptitudes, progress in school to date, study habits, etc.
2. Schedule further counseling sessions as needed.
3. Arrange for the services of others (school psychologist, testing department, other technical area instructor if student is uncertain of interest in civil engineering technology).

TEXTS AND REFERENCES

Johnson. *Engineering: Principles and Problems*

U.S. Department of Health, Education, and Welfare, Office of Education. *Putting Technicians to Work*

Current magazine and newspaper articles

VISUAL AND TRAINING AIDS

Coronet Films, Coronet Building, Chicago, Ill.
Aptitudes and Occupations
Your Earning Power

Encyclopaedia Britannica Films, Inc., 1150 Wilmette Ave., Wilmette, Ill.
Planning Your Career

Iowa State University, Ames, Iowa
Getting Acquainted With Engineering

Vocational Guidance Films, Des Moines, Iowa
Engineering

Charts and graphs illustrating employment trends in industry

Job classification and qualification charts

Sample intelligence, aptitude, and personality tests

TECHNICAL REPORTING

HOURS REQUIRED

Class, 2; Laboratory, 0; Credit, 2.

Description

A natural extension of the course in Communication Skills, intended to help the student achieve greater facility in his basic skills previously acquired. The student is introduced to the practical aspects of preparing reports and communicating within groups. The use of graphs, charts, sketches, diagrams, and drawings to present ideas and significant points is an important part of this course.

Instruction Suggestions

Emphasis should be upon techniques for collecting and presenting scientific data by means of informal and formal reports, and special types of technical papers. Forms and procedures for technical reports should be studied, and a pattern established for all forms to be submitted in this and other courses.

Much of the subject matter for this course may be required reports written for technical courses. The subject matter should be coordinated with material learned in Technical Drawing and with that of the course studied concurrently, Advanced Drafting.

MAJOR DIVISIONS	Class hours
I. Reporting	3
II. Writing Technical Reports	12
III. Illustrating Technical Reports	4
IV. The Research Paper	3
V. Oral Reporting	4
VI. Group Communication and Participation	6
Total	32

I. Reporting.

Class: 3 hours.

1. Nature and types of reports.
2. Objective reporting.
3. The problem concept.
4. The scientific method.
   a. Meaning of the method.
   b. Characteristics of the scientific method.
   c. Essentials of scientific style.

    d. Importance of accuracy and intellectual honesty in observation and recording.
    e. Legal importance of recorded data and log books.
  5. Techniques of exposition.
    a. Definitions.
    b. Progression.
    c. Elements of style.
    d. Analysis of examples.
    e. Methods of slanting a report.
  6. Critical evaluation of a report.

II. Writing Technical Reports.
  Class: 12 hours.
  1. Characteristics of technical reports.
  2. Report functions.
  3. Informal reports.
    a. Memorandum reports.
    b. Business letter reports.
    c. Progress reports.
    d. Outline reports.
  4. The formal report.
    a. Arrangement.
      (1) Cover and title page.
      (2) Table of contents.
      (3) Summary of abstracts.
      (4) Body of the report.
      (5) Bibliography and appendix.
      (6) Graphs, drawings, or other illustrations.
    b. Preparation.
      (1) Collecting, selecting, and arranging material.
      (2) Writing and revising the report.
  5. Special types of papers.
    a. The abstract.
    b. Process explanations.
    c. The case history.
    d. The book review.

III. Illustrating Technical Reports.
  Class: 4 hours.
  1. Illustrations as aids to brevity and clarity.
  2. Use of technical sketching and drawings.
  3. Use of pictorial drawings and sketches.
  4. Use of diagrammatic representation.
    a. Electrical diagrams and symbols.
    b. Process flow diagrams.
    c. Instrumentation diagrams.
    d. Bar charts, pie diagrams, and similar presentation of data.
  5. Graphical presentation of data.
    a. Graphs—types of graph paper.
    b. Choice of scale for graphs.
    c. Points and lines, and use of data from graphs.
  6. Use of photographs.
  7. Selection of appropriate illustrations.
    a. Availability.
    b. Cost of preparation.
    c. Maximum brevity and clarity of presentation.

IV. The Research Paper.
  Class: 3 hours.
  1. Subject and purpose.
  2. Source materials: bibliographical tools, periodical indexes, the library.
  3. Organizing the paper.
    a. A working bibliography.
    b. Notes and the outline.
    c. The rough draft.
    d. Quoting and footnoting.
    e. The final paper.
  4. Oral and written presentation of the paper.

V. Oral Reporting.
  Class: 4 hours.
  1. Organization of material for effective presentation.
  2. Formal and informal reports.
  3. Use of notes.
  4. Use of slides, exhibits.
  5. Proper use of the voice.
  6. Elimination of objectionable mannerisms.
  7. Introductions.

VI. Group Communication and Participation.
  Class: 6 hours.
  1. The problem-solving approach.
    a. Stating and analyzing the problem.
    b. Proposing solutions.
    c. Selecting and implementing a solution.
  2. Participating in group communication.
    a. The chairman—duties and qualifications.
    b. Rules of order.
    c. Panel discussion and symposium.
    d. Group investigation.

TESTS AND REFERENCES

Baird and Knower. *Essentials of General Speech*
———. *General Speech: An Introduction*
Bordeaux and Tanaka. *How to Talk More Effectively*
Crouch and Zetler. *Guide to Technical Writing*
Dean and Bryson. *Effective Communication*
Harwell. *Technical Communication*
Hicks. *Successful Technical Writing*
Kegel and Stevens. *Communication: Principles and Practice*
Macrorie. *The Perceptive Writer, Reader, and Speaker*
Marder. *The Craft of Technical Writing*
Perrin and Smith. *The Perrin-Smith Handbook of Current English*
Rhodes. *Technical Report Writing*
Roget. *New Roget's Theasurus of the English Language in Dictionary Form*
Schutte and Steinberg. *Communication in Business and Industry*
Souther. *Technical Report Writing*
Thompson. *Fundamentals of Communication*
Warriner and Griffith. *English Grammar and Composition: A Complete Handbook*
Witty. *How To Become a Better Reader*
Young and Symonik. *Practical English: An Introduction to Composition*
Zetler and Crouch. *Successful Communication in Science and Industry*

VISUAL AND TRAINING AIDS

McMurry-Gold Productions, 139 South Beverly Dr., Beverly Hills, Calif.
Person to Person Communication. 13 min. 16 mm., sound
National Educational Television Film Service, Audio-Visual Center, Indiana University, Bloomington, Ind. Produced by Hayakawa (Language in Action Series).
Experience as Give and Take. 29 min. 16 mm., sound
Talking Ourselves Into Trouble. 29 min. 16 mm., sound
Words That Don't Inform. 29 min. 16 mm., sound
National Safety Council, 425 North Michigan Ave., Chicago, Ill.
It's an Order. 12 min. 16 mm., sound

MATERIALS

(Chemistry and Properties)

Hours Required

Class, 1; Laboratory, 3; Credit, 3.

Description

An introductory course in the fundamental nature of matter and how chemical reactions take place to form compounds. The origin and use of construction materials and characteristics and use of soils, aggregates, and bitumens as construction materials are presented in detail. Initial concepts of soil characteristics and origin are contrasted with those of rock and its characteristics as a course in both aggregates and concrete. Emphasis is given in class and laboratory to applications of properties of materials, and to field and laboratory testing for identification, quality control, and adherence to specifications. Common miscellaneous materials encountered in construction are also considered. A description of the chemical nature, reactivity, and properties, as well as of physical properties is presented for each material studied.

Instruction Suggestions

The laboratory sessions should be one 3-hour period each week. Students should work together for major projects; two- or three-man groups for minor projects. Whenever possible, procedures followed in the laboratory are to be based on the Standard Specifications of the American Society for Testing Materials, the American Association of State Highway Officials, or the American Concrete Institute. The material specifications of State highway departments should also be considered.

Where no standards have been established for certain tests, commonly accepted procedure should be followed. Since strength tests on concrete samples will be made at 7, 14, and 28 days, time should be allotted for this purpose within the overall schedule. A complete notebook covering the laboratory work for this course should be kept by each student.

	Hours	
Major Divisions	*Class*	*Laboratory*
I. Chemical Properties	6	6
II. Soils, Rocks, and Aggregates	7	9
III. Properties of Portland Cement and Concrete	9	15
IV. Properties of Bituminous Materials	7	15
V. Miscellaneous Materials	3	3
Total	32	48

I. Chemical Properties.
  A. Class: 6 hours.
    1. Materials: the constituents of matter.
    2. Chemical combinations: elements and compounds.
    3. Oxygen and oxidation.
    4. Hydrocarbons.
    5. Acids, bases, salts.
    6. The carbon-silicon family.

B. Laboratory: 6 hours.
  1. Study materials laboratory procedures, emphasizing practice of safety, cleanliness, and precision.
  2. Take samples of several types of materials, measure, and prepare for a standard test of each.
  3. Study several simple examples of chemical reactions which form compounds.
  4. Perform simple experiments demonstrating separation of compounds by gravity, by change of state, and by difference in solubility.

II. Soils, Rocks, and Aggregates.
  A. Class: 7 hours.
    1. Geologic history and origin.
    2. Identification of soils and rocks.
    3. Characteristics.
    4. Index properties; Atterberg limits.
    5. Mineralogical content.
    6. Weight volume relations.
    7. Structure and consistency.
    8. Soil classification systems.
    9. Aggregates: characteristics and properties.
    10. Origin and character of soil and rock deposits.
  B. Laboratory: 9 hours.
    1. Study and practice laboratory procedures identified with dry versus wet weight of materials; visual classification of soils and aggregates; and soil texture, color, and structure.
    2. Study and test for Atterberg limits: liquid, plastic, and shrinkage limits, plasticity index and shrinkage ratio for a soil.
    3. Continue study of Atterberg limits; determine grain sizes in a soil by sieving and hydrometer analysis.
    4. Determine maximum density and optimum water content values for a soil.

III. Properties of Portland Cement and Concrete.
  A. Class: 9 hours.
    1. Types, manufacture, function, use; chemistry of cement and concrete.
    2. Grading, shipping, storage, testing.
    3. Fundamentals of concrete.
    4. Cement-aggregate-water relations.
    5. Design of concrete mixes.
    6. Mixing, sampling, and testing of concrete, including air-entrained.
    7. Handling, placing, finishing, curing.
    8. Inspection of work; cracks and joints.
    9. Prestressed concrete: theory and preparation.
    10 Special types of concrete admixtures.
    11. Compression and flexural properties and testing.
  B. Laboratory: 15 hours.
    1. Make tests following procedures for weighing and sieving for cement and aggregates; make unit weight tests.
    2. Make tests for specific gravity; study water-to-cement ratio tests to show effect of varying the water-cement ratio for a given aggregate-cement ratio and percentage of sand in total aggregate. Make a test to determine the bulking factor of a given aggregate.
    3. Make concrete batches for curing and placing tests; determine unit weight and perform slump tests; make strength tests at 7, 14, and 28 days. Vary the curing conditions to show the effects of variation in curing to compression strength of concrete.
    4. Make a mortar-voids test; make a surface moisture test.
    5. Study and illustrate correct design practice for a given strength and slump.

IV. Properties of Bituminous Materials.
  A. Class: 7 hours.
    1. Definitions, types, and grades of asphaltic materials.
    2. Characteristics and index properties; flash and fire points, viscosity, resistance to penetration.
    3. Other bituminous characteristics; float tests, softening points.
    4. Uses of bituminous materials: as binders.
    5. Asphaltic concrete.
    6. Proportioning and placing of bituminous mixes.
    7. Stability: sampling and testing.
    8. Bitumens as waterproofing and stabilizing.
  B. Laboratory: 15 hours.
    1. Perform flash and fire point tests to determine the temperature at which an

asphalt will first flash and then burn continuously for 5 seconds.

2. Make a penetration test to determine value for semisolid and solid asphalt cement.
3. Make Saybolt Viscosity Tests for a cutback asphalt or emulsified asphalt and Engler Viscosity Test for low-viscosity road tars.
4. Make a float test to control consistency of high viscosity road tars; make a softening point test to determine the test value of tar and asphalt cement, using the ring and ball apparatus.

V. Miscellaneous Materials.
   A. Class: 3 hours.
      1. Reinforcing materials: bars, wire, mesh.
      2. Placement of reinforcing.
      3. Brick, tile, glass, aluminum, wood: characteristics, use, and specifications.
      4. Paints and protective coatings: characteristics, use, and specifications.
      5. Epoxy resins.
   B. Laboratory: 3 hours.
      Study and perform, as time allows, specifications tests, field inspection, and testing of miscellaneous materials.

TEXTS AND REFERENCES

The Asphalt Institute. *Asphalt as a Material*
———. *Asphalt Handbook*
Bauer and Hollon. *Laboratory Manual for Plain Concrete*
Bauer and Thornburn, *Introductory Soil and Bituminous Testing*
Burrows, Arthur, and Smith. *Semimicro Laboratory Exercises in General Chemistry*
Deming. *Practical Laboratory Chemistry*
Hough. *Basic Soils Engineering*
Iowa State Technical Institute. *Laboratory Manual: Soils Technology*
Larson. *Portland Cement and Asphalt Concretes*
Peck and others. *Foundation Engineering*
Portland Cement Association. *Concrete Pavement Inspector's Manual*
———. *Concrete Pavement Manual*
———. *Design and Control of Concrete Mixtures*
———. *Soil Primer*
Ritter. *An Introduction to Chemistry*
Sisler, Stewart, and Lippincott. *A Systematic Laboratory Course in General Chemistry*
Steiner and Campbell. *Laboratory Experiments in General Chemistry*

VISUAL AND TRAINING AIDS

The Asphalt Institute, College Park, Md.
Asphalt Through the Ages. 13½ min., 16 mm., color, sound, 1957.
Seal Coats. 16½ min., 16 mm., color, sound, 1955.

STRENGTH OF MATERIALS

Hours Required

Class, 3; Laboratory, 2; Credit, 4.

Description

This course is an introduction to the strength of materials method of determining the internal stresses and deflections of basic local carrying members. The 2-hour laboratory period supplements the classroom presentation by giving the students a clearer understanding of the response of components and structures to external loads.

Instruction Suggestions

In this course it is possible to change the order of presentation of some topics to follow either the instructor's desire or a particular text. For example, some instructors may wish to introduce state of stress at a point and Mohr's circle early in the semester in order to utilize these ideas wherever possible throughout the course. Care must be taken to insure topic coverage in the classroom prior to performing an experiment in the laboratory. It will be important for the laboratory instructor to correlate the behavior of the materials tested with the theoretical states of stress studied in the classroom. Emphasis should be placed on having the students solve many carefully selected problems.

	Hours	
Major Divisions	Class	Laboratory
I. Properties of Materials and Central Loads	6	16
II. Structural Joints	4	2
III. Torsion	5	0
IV. Beams	9	4
V. Deflection of Beams	7	4
VI. Combined Loads	3	0
VII. Columns	8	4
VIII. Combined Stress Relations and Theories of Failure	6	2
Total	48	32

I. Properties of Materials and Central Loads.
   A. Class: 6 hours.
      1. Definitions.
      2. Stresses due to central loads.
      Strains 3. due to central loads.

4. Stress-strain curves.
5. Thermal stresses.
6. Thin-walled cylinders.
7. Stresses on an oblique plane.

B. Laboratory: 16 hours.

1. Introduce the functioning of various testing machines and determine a load-deformation curve for steel.
2. Determine a tensile stress-strain curve for structural steel.
3. Determine tensile stress-strain curves for aluminum and cast iron.
4. Determine compression stress-strain curves for structural steel and cast iron.
5. Calculate mechanical properties from the stress-strain curves for the various materials previously tested.
6. Determine a creep-time curve for a material (concrete suggested).
7. Determine stress concentration factors.
8. Perform hardness tests by several methods on various materials.

II. Structural Joints.

A. Class: 4 hours.

1. Riveted joints.
2. Welded joints.

B. Laboratory: 2 hours.

1. Test riveted joints for various types of failure.
2. Test various types of welded joints.

III. Torsion.

A. Class: 5 hours.

1. Review moment of inertia.
2. Torsion formula.
3. Angle of twist.

B. Laboratory: 0 hours.

IV. Beams.

A. Class: 9 hours.

1. Bending moments.
2. Flexure formula.
3. Shear and moment diagrams.
4. Shearing stress.

B. Laboratory: 4 hours.

1. Demonstrate electric resistence strain gages and plane stress-strain relations.
2. Measure elastic strains in a beam.

V. Deflection of Beams.

A. Class: 7 hours.

1. Relation between load and radius of curvature.
2. Relation between load and deflection.
3. Moment-area method.
4. Conjugate beam method of computing slope and deflection of beam.

B. Laboratory: 4 hours.

1. Determine a load-deflection curve for a structural steel beam up to maximum load-carrying capacity.
2. Practice using the moment-area method for determining deflection of beams.

VI. Combined Loads.

A. Class: 3 hours.

1. Bending and axial loads.
2. Eccentric loads.

B. Laboratory: 0 hours.

VII. Columns.

A. Class: 8 hours.

1. Ideal columns.
2. Real columns.
3. Euler equation.
4. Intermediate column equations.
5. Design.
6. End conditions.
7. Eccentric loads.

B. Laboratory: 4 hours.

1. Determine the load-carrying curve for a series of columns of varying length.
2. Verify the effect of end conditions on load-carrying capacity of columns.

VIII. Combined Stress Relations and Theories of Failure.

A. Class: 6 hours.

1. State of stress at a point.
2. Mohr's circle.
3. Maximum shear stress.
4. Maximum normal stress.
5. Maximum strain theory.

B. Laboratory: 2 hours.

Measure strains for combined bending and twisting load on a hollow tube.

TEXTS AND REFERENCES

American Institute of Steel Construction. *Manual of Steel Construction*
Bassin and Brodsky. *Statics and Strength of Materials*
Draffin and Collins. *Statics and Strength of Materials*

Jensen. *Applied Strength of Materials*
Levinson. *Mechanics of Materials*
Olsen. *Elements of Mechanics of Materials*
Seely and Smith. *Resistance of Materials*

VISUAL AND TRAINING AIDS

University of Illinois, Urbana, Ill.
  Video tapes demonstration, various experiments, black and white, 1962
    No. 1. *Load and Deformation.* Tape 1, 40 min.; Tape 2, 31 min.
    No. 2. *Stress and Strain.* Tape 1, 51 min.; Tape 2, 45 min.
    No. 3. *Strain Hardening.* Tape 1, 50 min.; Tape 2, 51 min.
    No. 4. *True Stress and Strain.* Tape 1, 50 min.; Tape 2, 47 min.
    No. 5. *Flow and Fracture.* Tape 1, 51 min.; Tape 2, 33 min.
    No. 6. *Time and Temperature Effects* (Part I). Tape 1, 50 min.; Tape 2, 41 min.
    No. 7. *Time and Temperature Effects* (Part II). Tape 1, 50 min.; Tape 2, 50 min.
    No. 8. *Stress Concentration.* Tape 1, 31 min.; Tape 2, 48 min.
    No. 9. *Hardness.* Tape 1, 50 min.; Tape 2, 42 min.
    No. 10. *Torsion.* Tape 1, 50 min.; Tape 2, 40 min.
    No. 11. *Bending.* Tape 1, 49 min.; Tape 2, 40 min.
    No. 12. *Fatigue.* Tape 1, 51 min.; Tape 2, 41 min.
    No. 13. *Multiaxial State of Stress.* Tape 1, 51 min.; Tape 2, 50 min.
    No. 14. *Columns.* Tape 1, 50 min.; Tape 2, 22 min.

LEGAL AND ECONOMIC ASPECTS OF ENGINEERING

HOURS REQUIRED

Class, 2; Laboratory, 0; Credit, 2.

Description

This course is an introductory study of legal relations and the economic problems in engineering work, such as bidding procedures, bonding, letting, awarding of contracts, torts, negligence, trespass to real estate, violation of the right of lateral support, Workman's Compensation, and agency, master-servant, and employee injuries. It covers the law of real property, ownership, easements, licenses, boundaries, and eminent domain. Also included are the economics of estimating and evaluating engineering projects, present worth and annual cost studies, accounting practices, depreciation, and types of costs and their influences on economy studies.

Instruction Suggestions

The legal subjects are best treated by an informal lecture-discussion. Students should be assigned reading in the text in advance of each class period, such reading to include examples of factual situations giving rise to application of the rules of law. Practical factors that often govern the outcome of a legal controversy should be given due consideration.

Lectures on the economic subject matter should also be supported with numerous example problems. Homework problems should be assigned and students should be selected to present their solutions to the class and explain the reasoning used in solving the problems. The assumptions used in making economic analyses should be stressed.

MAJOR DIVISIONS	Class hours
I. Nature of the Law	2
II. Contracts	6
III. Construction Contracts and Specifications	6
IV. Performance of Contracts	2
V. Agency	2
VI. Torts and Crimes	2
VII. Property	3
VIII. Mathematics of Finance	2
IX. Comparative Cost Studies	4
X. Evaluating Costs	3
Total	32

I. Nature of the Law.
  Class: 2 hours.
  1. Origin and development of the law.
  2. Sources of law.
  3. Legal rights and duties.
  4. Court system.
  5. Trial procedure and evidence.

II. Contracts.
  Class: 6 hours.
  1. Offer and acceptance.
  2. Consideration.
  3. Competent parties.
  4. Legality of purpose.
  5. Statute of Frauds.

III. Construction Contracts and Specifications.
  Class: 6 hours.
  1. Precontract procedures.
    a. Advertisements.
    b. Bids and bid bonds.
    c. Awards, and performance and payment bonds.
    d. Component parts of construction contracts

    e. Standard clauses of construction contracts.
  2. Technical specifications.

IV. Performance of Contracts.

Class: 2 hours.

1. Discharge.
2. Breach.
3. Damages and remedies.
4. Duties and rights of inspectors.

V. Agency.

Class: 2 hours.

1. Master-servant, principal agent, and/or independent contractor relationships.
2. Creation of agency and the authority of the agent.
3. Tort and contract liability of the master and principal.
4. Workmen's compensation.
5. Insurance.

VI. Torts and Crimes.

Class: 2 hours.

1. Negligence.
2. Trespass.
3. Violation of the right of lateral support.
4. Nuisance.
5. Insurance.

VII. Property.

Class: 3 hours.

1. Definition of real property.
2. Fixtures.
3. Ownership and title.
4. Easements and licenses.
5. Boundaries.
6. Eminent domain.
7. Border rights.
8. Right of way.
9. Deed descriptions and surveys.

VIII. Mathematics of Finance

Class: 2 hours.

1. Equivalence.
2. Compound interest formulas.

IX. Comparative Cost Studies.

Class: 4 hours.

1. Present worth studies.
2. Annual cost studies.
3. Value of incremental investment.

X. Evaluating Costs.

Class: 3 hours.

1. Cost accounting practice.
2. Overhead allocation.
3. Fixed, variable, sunk, and incremental costs.
4. Depreciation.

TEXTS AND REFERENCES

Abbett. *Engineering Contracts and Specifications*
Brown. *Boundary Control and Legal Principles*
——— and Eldridge. *Evidence and Procedures for Boundary Location*
Clark. *A Treatise on the Law of Surveying and Boundaries*
Deatherage. *Construction Company Organization and Management*
Dunham and Young. *Contracts, Specifications, and Law for Engineers*
Grant and Ireson. *Principles of Engineering Economy*
Mead and Akerman. *Contracts, Specifications, and Engineering Relations*
Nord. *Legal Problems in Engineering*
Sadler. *The Specifications and Law on Engineering Works*
Simpson and Dillavou. *Law for Engineers and Architects*
Skelton. *The Legal Elements of Boundaries and Adjacent Properties*
Thuesen. *Engineering Economy*
Vaughn. *Legal Aspects of Engineering*
Woods and DeGarmo. *Engineering Economy*

GENERAL COURSES

COMMUNICATION SKILLS

Hours Required

Class, 3; Laboratory, 0; Credit, 3.

Description

The course places emphasis throughout on exercises in writing, speaking, and listening. Analysis is made of each student's strengths and weaknesses. The pattern of instruction is geared principally to helping students improve skills in areas where common weaknesses are found. The time allotments for the various elements within major divisions will depend upon the background of the class.

A brief consideration of technical reporting is included early in the course because of its importance in the orientation of the technician to his development and use of communication skills.

Major Divisions	*Class hours*
I. Communication and the Technical Specialist	2
II. Sentence Structure	6
III. Using Resource Materials	4
IV. Written Expression	20
V. Talking and Listening	10
VI. Improving Reading Efficiency	6
Total	48

I. Communication and the Technical Specialist.

Class: 2 hours.

1. Why the technical specialist must be proficient in the art of communication.
2. Why skill in written communication is essential.
   a. Statements of facts.
   b. Expression of ideas.
   c. Technical reporting.
      (1) Formal.
      (2) Informal.
   d. Use of graphics to illustrate written communications.
3. Why skill in oral communication is essential.
   a. Person to person expression of ideas and thoughts.
   b. Verbal reporting.
4. Diagnostic tests.

II. Sentence Structure.

Class: 6 hours.

1. Review of basic parts of speech.
2. What makes complete sentences.
3. Use and placement of modifiers, phrases, and clauses.
4. Sentence conciseness.
5. Exercises in sentence structure.

III. Using Resource Materials.

Class: 4 hours.

1. Orientation in use of school library.
   a. Location of reference materials, *Reader's Guide to Periodical Literature*, etc.
   b. Mechanics for effective use.
   c. Dewey Decimal System.
2. Dictionaries.
   a. Types of dictionaries.
   b. How to use dictionaries.
   c. Diacritical markings and accent marks.
3. Other reference sources.
   a. Technical manuals and pamphlets.
   b. Bibliographies.
   c. Periodicals
   d. *The Industrial Arts Index.*
4. Exercises in use of resource materials.
   a. *Reader's Guide to Periodical Literature.*
   b. Atlases.
   c. Encyclopedias.
   d. Other.

IV. Written Expression (emphasis on student exercises).

Class: 20 hours.

1. Diagnostic test.
2. Paragraphs.
   a. Development.
   b. Topic sentence.
   c. Unity of coherence.
3. Types of expression.
   a. Inductive and deductive reasoning.
   b. Figures of speech.
   c. Analogies.
   d. Syllogisms.
   e. Cause and effect.
   f. Other.

4. Written exercises in paragraph construction.
5. Descriptive reporting.
    a. Organization and planning.
    b. Emphasis on sequence, continuity, and limitation to pertinent data.
6. Letterwriting.
    a. Business letters.
    b. Personal letters.
7. Mechanics.
    a. Capitalization.
    b. Punctuation—when to use.
        (1) Period, question mark, and exclamation point.
        (2) Comma.
        (3) Semicolon.
        (4) Colon.
        (5) Dash.
        (6) Parentheses.
        (7) Apostrophe.
    c. Spelling.
        (1) Work division—syllabication.
        (2) Prefixes and suffixes.
        (3) Word analysis and meaning—context clues, phonetics, etc.
8. Exercises in mechanics of written expression.

V. Talking and Listening (emphasis on student exercises).

Class: 10 hours.

1. Diagnostic testing.
2. Organization of topics or subject.
3. Directness in speaking.
4. Gesticulation and use of objects to illustrate.
5. Conversational courtesies.
6. Listening faults.
7. Taking notes.
8. Understanding words through context clues.
9. Exercises in talking and listening.

VI. Improving Reading Efficiency.

Class: 6 hours.

1. Diagnostic test.
2. Reading habits.
    a. Correct reading posture.
    b. Light sources and intensity.
    c. Developing proper eye span and movement.
    d. Scanning.
    e. Topic sentence reading.
3. Footnotes, index, bibliography, cross-references, etc.
4. Techniques of summary.
    a. Outline.
    b. Digest or brief.
    c. Critique.
5. Exercise in reading improvement.
    a. Reading for speed.
    b. Reading for comprehension.

TEXTS AND REFERENCES

Baird and Knower. *Essentials of General Speech*

———. *General Speech, and Introduction*

Beardsley. *Thinking Straight*

Bordeaux and Tanaka. *How To Talk More Effectively*

Buckler and McAvoy. *American College Handbook of English Fundamentals*

Crouch and Zetler. *Guide to Technical Writing*

Dean and Bryson. *Effective Communication*

DeVitis and Warner. *Words in Context: A Vocabulary Builder*

Gerber. *The Writer's Resource Book*

Harwell. *Technical Communication*

Kegel and Stevens. *Communication: Principles and Practice*

Lee. *Language Habits in Human Affairs*

Macrorie. *The Perceptive Writer, Reader, and Speaker*

Marder. *The Craft of Technical Writing*

Perrin and Smith. *The Perrin-Smith Handbook of Current English*

Roget. *New Roget's Thesaurus of the English Language in Dictionary Form*

Schutte and Steinberg. *Communication in Business and Industry*

Stewart and others. *Business English and Communication*

Strunk and White. *The Elements of Style*

Thompson. *Fundamentals of Communication*

Tracy and Jennings. *Handbook for Technical Writers*

Warriner and Griffith. *English Grammar and Composition: A Complete Handbook*

Witty. *How To Become a Better Reader*

Young and Symonik. *Practical English: An Introduction to Composition*

Zetler and Crouch. *Successful Communication in Science and Industry*

VISUAL AND TRAINING AIDS

Coronet Films, Inc., Coronet Building, Chicago, Ill.

Improve Your Punctuation. 11 min., 16 mm., sound, black and white, or color. (Summary: Guides teacher and class work on punctuation trouble spots, covering the chief uses of the comma, the semicolon, the colon, the question mark, and the quotation mark. Stresses the use of punctuation as a means of clarifying written communication.)

National Education Television Film Service, Audio-Visual Center, Indiana University, Bloomington, Ind.

The Definition of Language. 29 min., 16 mm., sound. Produced by Henry Lee Smith. (Language in Linguistics Series)

Dialects. 29 min., 16 mm., sound. Produced by Henry Lee Smith. (Language in Linguistics Series)

How to Say What You Mean. 29 min., 16 mm., sound. Produced by S. I. Hayakawa. (Language in Action Series)

Language and Writing. 29 min., 16 mm., sound. Produced by Henry Lee Smith. (Language in Linguistics Series)

The Task of the Listener. 29 min., 16 mm., sound. Produced by S. I. Hayakawa. (Language in Action Series)

What is the Meaning? 29 min., 16 mm., sound. Produced by S. I. Hayakawa. (Language in Action Series)

Norwood Films, Inc., 926 New Jersey Ave. NW., Washington, D.C., 20001

Effective Writing. 19 min., 16 mm., sound, black and white. U.S. Department of the Air Force. Order No. TF 1–5072. (Summary: Describes communication from the concrete symbols of the cave man to the prolexities and ambiguities of some current government writing. Explains the rules for organizing material and gives various examples of ineffective writing with recommendations for improvement.) May be borrowed from U.S. Air Force, Film Library Center, 8900 South Broadway, St. Louis, Mo., 63125.

Practical English Usage I, Lecture 1: The Tools of Language. 30 min., 16 mm., sound, black and white. U.S. Department of Defense. (Summary: Discusses the parts of speech—nouns, pronouns, verbs, adjectives, adverbs, conjunctions, prepositions, and interjections—and describes the use of words as different parts of speech.)

Practical English Usage I, Lecture 10: Writing Clear Sentences: Making Words Agree. 30 min., 16 mm., sound, black and white. U.S. Department of Defense. (Summary: Explains agreement of subject and verb, of pronoun and antecedent, and explains the need for agreement in special cases.)

Practical English Usage I, Lecture 13: Dressing Up Sentences: Parallelism: Avoidance of Shifts. 30 min., 16 mm., sound, black and white. U.S. Department of Defense. (Summary: Explains the use of parallel ideas in parallel form, coordinated ideas and correlative constructions, and incomplete parallelism in sentences; discusses avoidance of shifts in subject and verb and the use of the passive voice of verbs.)

Practical English Usage I, Lecture 14: Dressing Up Sentences: Word Economy (Word Reduction). 30 min., 16 mm., sound, black and white. U.S. Department of Defense. (Summary: Discusses the elimination of superfluous words and repetition in sentences, and the use of double negatives, the reduction of clauses to phrases and phrases to words, and the use of suitable words.)

Practical English Usage I, Lecture 15: Dressing Up Sentences: Variation. 30 min., 16 mm., sound, black and white. U.S. Department of Defense. (Summary: Explains how to vary a sentence by beginning with a transposed appositive, a modifier, or a phrase; discusses the use of subordination, complex sentences, and variation in sentence length.)

Practical English Usage I, Lecture 16: Dressing Up Sentences: Vocabulary. 30 min., 16 mm., sound, black and white. U.S. Department of Defense. (Summary: Explains how to avoid trite expressions and mixed figures of speech in a sentence and discusses the use of idiomatic and appropriate words.)

INDUSTRIAL ORGANIZATIONS AND INSTITUTIONS

HOURS REQUIRED

Class, 3; Laboratory, 0; Credit, 3.

Description

A description and analysis of the roles of labor and management in the economy of the United States is presented. Approximately half of the classroom time is devoted to labor-management relations, including the evolution and growth of the American labor movement and the development and structure of American business management. A study is made of the legal framework conducted and the responsibilities of each in a democratic system of government. The second half of the course pertains to labor-economics as applied to the forces affecting labor supply and demand, problems of unemployment and wage determination on the national, plant, and individual levels. Emphasis centers upon current aspects of industrial society with historical references intended only as background.

MAJOR DIVISIONS	*Class hours*
I. Labor in an Industrial World	9
II. Management in an Industrial Society	9
III. The Collective Bargaining Process	12
IV. Dynamics of the Labor Market	8
V. Wage Determination	7
VI. Balance Sheet of Labor-Management Relations	3
Total	48

I. Labor in an Industrial World.
  Class: 9 hours.
  1. Nature and scope of the Industrial Revolution.
    a. The factory system.
    b. Occupational trends.
    c. Mechanisms of adjustment.
  2. Evolution of American labor unions.
    a. Nature of early unions; basic system of craft unions.

    b. Organization by unions for solving problems.
    c. Emergence of business unionism.
    d. Changing role of government.
  3. Structure and objectives of American unions.
    a. Objectives in collective bargaining.
    b. Political objectives and tactics.
    c. Structure of craft and industrial unions.
    d. Movement toward unity—the AFL–CIO merger.
II. Management in an Industrial Society.
  Class: 9 hours.
  1. Rise of big business.
    a. Economic factors.
    b. Dominance of the corporate firm.
    c. Government, public policy, and big business.
  2. The Managerial Revolution.
    a. Changing patterns of ownership and management.
    b. Scientific management.
    c. Twentieth-century trends.
  3. Structure and objectives of American industry.
    a. Production for profit; an affluent society.
    b. Structure of industry—organizational forms.
    c. Ethics in a competitive economy.
III. The Collective Bargaining Process.
  Class: 12 hours.
  1. Legal framework.
    a. Common law provisions.
    b. Growth of statute laws.
      (1) Antitrust laws; aid to emergence of collective bargaining.
      (2) Addamson and La Follette Laws.
      (3) Norris-La Guardia Act.
      (4) Wagner Act.
      (5) Taft-Hartley Act.
      (6) Landrum-Griffin Act and beyond.
  2. Management and collective bargaining.
  3. Bargaining procedures and tactics, including conciliation and mediation process.
  4. Issues in collective bargaining.
    a. Security issues.
    b. Working conditions.
    c. Safety provisions and safety education.
    d. Money matters.
  5. Strikes and lockouts: tactics and prevention.
  6. Evaluation of collective bargaining.
IV. Dynamics of the Labor Market.
  Class: 8 hours.
  1. Labor supply and the market.
    a. Level and composition of the labor force.
    b. Changing patterns of employment.
    c. Some questions about labor supply and the market.
  2. Reduction and control of unemployment.
    a. Types of unemployment.
    b. Proposed schemes of employment stabilization.
    c. Continuing problems.
  3. Labor mobility.
    a. Types of labor mobility.
    b. Deterrents to labor mobility.
    c. Suggested programs to improve labor mobility.
V. Wage Determination.
  Class: 7 hours.
  1. Wages, process, and employment.
    a. Meaning of wages.
    b. Wages and the productive process.
    c. The problem of inflation.
  2. Wages and the national income.
    a. Concepts of measurement and productivity.
    b. Determinants of productivity.
    c. Distribution of national income.
  3. Wage structures.
    a. Occupational differences.
    b. Geographic patterns.
    c. Industry patterns.
    d. Wage determination: plant level, individual wages.
VI. Balance Sheet of Labor-Management Relations.
  Class: 3 hours.
  1. Control and elimination of poverty in a modern industrial State.
    a. The extent of poverty.
    b. The attack on poverty.
    c. Trends and portents.

2. Justice and dignity for all in an industrial democracy.
    a. The worker—status and goals.
    b. Management—rights and responsibilities.
    c. The future of capitalistic society.

TEXTS AND REFERENCES

Bloom and Northrup. *Economics of Labor Relations*
Chamberlin. *The Economic Analysis of Labor Union Power*
Eells. *The Meaning of Modern Business: An Introduction to the Philosophy of Large Corporate Enterprise*
Fulkner. *American Economic History*
Geary. *The Background of Business*
Geogory. *Labor and the Law*
Grimshaw and Hennessey. *Organizational Behavior—Cases and Readings*
Kerr and others. *Industrialism and Industrial Man*
Leiserson. *American Trade Union Democracy*
McGregor. *The Human Side of Enterprise*
Pfiffner. *Administrative Organization*
Phelps. *Introduction to Labor Economics*
Reynolds. *Labor Economics and Labor Relations*
Richberg. *Labor Union Monopoly: A Clear and Present Danger*
Slichter, Healy, and Livernash. *The Impact of Collective Bargaining on Management*
Sultan. *Labor Economics*
Taft. *Economics and Problems of Labor*
U.S. Department of Labor. *The American Worker's Fact Book*
———, Bureau of Labor Statistics. *Interim Revised Projections of U.S. Labor Force—1965–75*

VISUAL AND TRAINING AIDS

The Brookings Institution, 1775 Massachusetts Ave., Washington, D.C.
Big Enterprise in the Competitive System. 40 min., 16 mm., sound, color
Coronet Films, Inc., Coronet Building, Chicago, Ill.
Labor Movement: Beginnings and Growth in America. 13½ min., 16 mm., sound
Encyclopaedia Britannica Films, Inc., 1150 Wilmette Ave., Wilmette, Ill.
Productivity—Key to Plenty. 22 min., 16 mm., sound
Working Together (a case history in labor management cooperation). 24 min., 16 mm., sound
McGraw-Hill Book Co., Inc., 330 West 42d St., New York, N.Y., 10036
Internal Organization. 10 min., 16 mm., sound
Job Evaluation and Merit Rating. 13 min., 16 mm., sound
Teaching Film Custodians, 25 West 43d St., New York, N.Y.
Bargaining Collectively. 10 min., 16 mm., sound
University of Indiana, Bloomington, Ind.
Decision: Constitution and the Labor Union. 29 min., 16 mm., sound

GENERAL AND INDUSTRIAL ECONOMICS

HOURS REQUIRED

Class, 3; Laboratory, 0; Credit, 3.

Course Description

A study designed to impart a basic understanding of the principles of economics and their implications, to develop the ability to follow an informed personal finance program, to aid in the practice of intelligent consumption, and to show the underlying relationship of cost control to success in industrial enterprise. The programs of problems worked upon by any technician in either research or production ultimately must be measured by a cost analysis. Awareness of this fact and a knowledge of elementary economics prepares the student for the cost-conscious environment of his future employment. It is suggested that the instruction in this course be based on this pragmatic approach and that students be encouraged to study examples from industry as they learn about industrial cost analysis, competition, creation of demand, economic production, and related aspects of applied economics.

MAJOR DIVISIONS	Class hours
I. Introduction	2
II. Economic Forces and Indicators	3
III. Natural Resources—The Basis of Production	3
IV. Capital and Labor	3
V. Business Enterprise	7
VI. Factors of Industrial Production Cost	8
VII. Price, Competition, and Monopoly	5
VIII. Distribution of Income	2
IX. Personal Income Management	2
X. Insurance, Personal Investments, and Social Security	3
XI. Money and Banking	3
XII. Government Expenditures, Federal and Local	3
XIII. Fluctuations in Production, Employment, and Income	2
XIV. The U.S. Economy in Perspective	2
Total	48

I. Introduction.
    Class: 2 hours.
        Basic economic concepts.

II. Economic Forces and Indicators.
    Class: 3 hours.
    1. Economics defined.
    2. Modern specialization.

3. Increasing production and consumption.
4. Measures of economic activity.
    a. Gross national product.
    b. National income
    c. Disposable personal income.
    d. Industrial production.
    e. Employment and unemployment

III. Natural Resources—The Basis of Production.

Class: 3 hours.

1. Utilization and conservation of resources.
2. Renewable resources.
3. Nonrenewable resources.
4. Future sources.

IV. Capital and Labor.

Class: 3 hours.

1. Tools (capital).
    a. The importance of saving and investment.
    b. The necessity for markets.
2. Large-scale enterprise.
3. Labor.
    a. Population characteristics.
    b. Vocational choice.
    c. General education.
    d. Special training.
    e. Management's role in maintaining labor supply.

V. Business Enterprise.

Class: 7 hours.

1. Forms of business enterprise.
    a. Individual proprietorship.
    b. Partnership.
    c. Corporation.
2. Types of corporate securities.
    a. Common stocks.
    b. Preferred stocks.
    c. Bonds.
3. Mechanics of financing business.
4. Plant organization and management.

VI. Factors of Industrial Production Cost.

Class: 8 hours.

1. Buildings and equipment.
    a. Initial cost and financing.
    b. Repair and maintenance costs.
    c. Depreciation and obsolescence costs.
2. Materials
    a. Initial cost and inventory value.
    b. Handling and storage costs.
3. Processing and Production.
    a. Methods of cost analysis.
    b. Cost of labor.
    c. Cost of supervision and process control.
    d. Effect of losses in percentage of original product compared to finished product (yield).
4. Packaging and shipping.
5. Overhead costs.
6. Taxes.
7. Cost of selling.
8. Process analysis, a means to lower costs.
9. Profitability and business survival.

VII. Price, Competition, and Monopoly.

Class: 5 hours.

1. Function of prices.
2. Price determination.
    a. Competitive cost of product.
    b. Demand.
    c. Supply.
    d. Interactions between supply and demand.
3. Competition, benefits, and consequences.
    a. Monopoly and oligopoly.
    b. Forces that modify and reduce competition.
    c. History of government regulation of competition.
4. How competitive is our economy?

VIII. Distribution of Income.

Class: 2 hours.

1. Increasing real incomes.
2. Marginal productivity.
3. Supply in relation to demand.
4. Incomes resulting from production.
    a. Wages.
    b. Interest.
    c. Rents.
    d. Profits.
5. Income distribution today.

IX. Personal Income Management.

Class: 2 hours.

1. Consumption—the core of economics.
2. Economizing defined.
3. Personal and family budgeting.
4. Analytical buying.
    a. Applying quality standards.

        - b. Consumers' Research and similar groups.
    - 5. The use of credit.
    - 6. Housing—owned or rented.
- X. Insurance, Personal Investments, and Social Security.
    - Class: 3 hours.
    - 1. Insurance defined.
    - 2. Life insurance.
        - a. Group, industrial, and ordinary life policies.
        - b. Types of policies—their advantages and disadvantages.
    - 3. Casualty insurance.
    - 4. Investments.
        - a. Savings accounts and government bonds.
        - b. Corporation bonds.
        - c. Corporation stocks.
        - d. Annuities.
        - e. Pension plans.
    - 5. Social Security.
        - a. Old-Age, Survivors and Disability Insurance.
        - b. Unemployment Compensation.
- XI. Money and Banking.
    - Class: 3 hours.
    - 1. Functions of money.
    - 2. The Nation's money supply.
    - 3. Organization and operation of a bank.
        - a. Sources of deposits.
        - b. The reserve ratio.
        - c. Expansion of bank deposits.
        - d. Sources of reserves.
    - 4. The Federal Reserve System.
        - a. Service functions.
        - b. Control of money supply.
    - 5. Federal Deposit Insurance Corporation.
- XII. Government Expenditures, Federal and Local.
    - Class: 3 hours.
    - 1. Economic effects.
    - 2. Functions of government.
    - 3. Analysis of government spending.
    - 4. Future outlook.
    - 5. Financing government spending.
        - a. Criteria of sound taxation.
        - b. Tax revenues in the United States.
        - c. Federal and State personal income taxes.
        - d. The corporate income tax.
        - e. The property tax.
        - f. Commodity taxes.
- XIII. Fluctuations in Production, Employment, and Income.
    - Class: 2 hours.
    - 1. Changes in aggregate spending.
    - 2. Output and employment.
    - 3. Other factors affecting economic fluctuations.
        - a. Cost-price relationships.
        - b. Fluctuations in demand for durable goods.
        - c. Involuntary fluctuation of supply of commodities.
        - d. Economic effects of war.
        - e. Inflation and deflation of currency value.
        - f. Economic effects of inventions and automation.
    - 4. Means of implementing fiscal policy.
    - 5. Government debt.
        - a. Purposes of government borrowing.
        - b. How burdensome is the debt?
        - c. Problems of debt management
- XIV. The U.S. Economy in Perspective.
    - Class: 2 hours.
    - 1. Recent economic changes.
        - a. Increased productivity and well-being.
        - b. Effects of war and depression.
        - c. New products and industries.
        - d. Increase in governmental controls.
    - 2. Present economic problems of the U.S. economy.
        - a. The world market—a community of nations.
        - b. International cooperation.
        - c. Maintenance of prosperity and progress.
        - d. Economic freedom and security.
    - 3. Communism.
        - Nature and control by Soviet State.
    - 4. Fascism.
    - 5. British socialism.
    - 6. Problems common to all economic systems.
    - 7. Special economic problems of the United States.

TEXTS AND REFERENCES

Blodgett. *Comparative Economic Systems*
Business Week (Weekly)
Consumer Bulletin (Monthly)
Consumer Reports (Monthly)
Donaldson and Pfahl. *Personal Finance*
Gordon. *Economics for Consumers*
Pond. *Essential Economics: An Introduction*
Samuelson. *Economics: An Introductory Analysis*

VISUAL AND TRAINING AIDS

McGraw-Hill Book Co., Inc., 330 West 42d St., New York, N.Y., 10036

- *Basic Economic Concepts.* 35 mm., filmstrip—set of 4 filmstrips. Average 40 frames each.
- *Business Cycles and Fiscal Policy.* 35 mm., filmstrip
- *Money, Prices, and Interest.* 35 mm., filmstrip
- *Savings and Investment.* 35 mm., filmstrip
- *Supply and Demand.* 35 mm., filmstrip

FACILITIES, EQUIPMENT, AND COSTS

PLANNING OF FACILITIES

Laboratories and the related classrooms, offices, and storage facilities required for teaching civil technology do not entail many special or unusual conditions. Any well-constructed building with suitable utility services such as water, heat, light, ventilation, and plumbing facilities may be used.

If possible, the engineering-materials and the strength-of-materials laboratories should be located on the ground floor, where provision can be made for solid foundations for the material mixing and testing machines, where suitable floor drains may be installed, and where a durable concrete floor can be provided. Such a location permits bulky and heavy items such as cement, asphalt, aggregate, and sand to be received and used with a minimum of transportation and handling of incoming materials, and facilitates removal of disposable waste products.

It is desirable to have a classroom located near the engineering-materials and the strength-of-materials laboratories. Both classrooms and laboratories should be well lighted, with a recommended minimum of 50 foot-candles of light at the table or desk tops. Fluorescent lighting has been found satisfactory for such facilities.

Hot and cold water, and steam service lines to laboratories and demonstration stations should be planned for the shortest length of piping consistent with laboratory arrangement. They should be hidden as far as practicable, but control points should be planned for safety, accessibility, and ease of maintenance. It is recommended that each laboratory have a master control panel with shutoff valves for each utility. This master control panel should have a door with lock so that utilities can be controlled at a central point and locked up.

Fuel gas is required in the bituminous laboratory. Gas lines should be installed with care, and should be protected to avoid damage and possible resulting fires.

Electrical services should provide both 110- and 220-volt current for civil technology laboratories. Some equipment used in the laboratory requires 110 volts, but heavy equipment usually requires 220-volt current.

In connecting electrical service to major items of laboratory equipment it is suggested that each be connected to a separate circuit breaker, and the circuits be designed with ample capacity so that when a number of students in the laboratory are using electrical apparatus the lines will not become overloaded. Each laboratory should have a separate master distribution control panel for electrical circuits.

For the purposes of this discussion, only the facilities specifically identifiable with the technical specialty are described. It is assumed that classrooms, offices, lecture rooms, and the necessary related facilities are available for teaching nonlaboratory courses. It is also assumed that there is a suitable laboratory for teaching Technical Physics I and II since the classrooms, laboratory facilities, and laboratory equipment required to teach the two physics courses are conventional and the details need not be presented here. However, the requirements for the technical specialty courses are unique and therefore the minimum facilities and equipment required are presented in some detail.

If plans are being made to start a civil technology program in an institution which already offers a program in mechanical design technology, or some other program teaching mechanical drawing or drafting, a careful analysis should be made of existing engineering drawing (drafting) room facilities and their potential capacity to provide the necessary facilities for the civil technology Technical Drawing courses. Naturally, if there already exist sufficient drafting room facilities and equipment to teach the civil technology Technical Drawing and Advanced

Drafting courses, new facilities such as those described here need not be installed.

Also, if Strength of Materials is taught as a part of a mechanical designor metallurgical curriculum in the institution, the strength-of-materials laboratory described here may not be needed, and adequate facilities for civil technology may be provided in the existing facilities or with some addition to them. However, joint use of these facilities requires planning carefully coordinated with the other departments, since it is essential that each department have sufficient equipment for its own needs. Consideration must also be given to whether or not existing equipment in other departments has the capacity, range of measurement, or other characteristics required for the civil technology program.

For purposes of this suggested guide, it is assumed that the facilities required for teaching neither Advanced Drafting nor Strength of Materials are available and that both therefore must be provided.

Drafting, Surveying, and Photogrammetry Laboratories

The ideal drafting and surveying classroom should contain large drafting tables with a full work station for each student. Half the tables may be equipped with parallel edges, but at least half should be equipped with drafting machines.

The photogrammetry course can be taught in either the drafting or surveying measurement laboratory. The large drawing tables provide suitable workspace for the work which must be done by the students in this course. The special apparatus and equipment needed for the course may be kept in the storeroom and moved into the classroom as needed.

Chalkboards should extend across the front of the room. White chalkboard is desirable, since projections of films or material from an overhead projector may be made directly on it. One side of the room should have bulletin boards for display of materials. The room should contain storage facilities for materials and supplies. If the reproduction room is adjacent to the drafting room, the upper part of the wall between them can be of glass to enable the drafting teacher to have visual supervision of the class at all times.

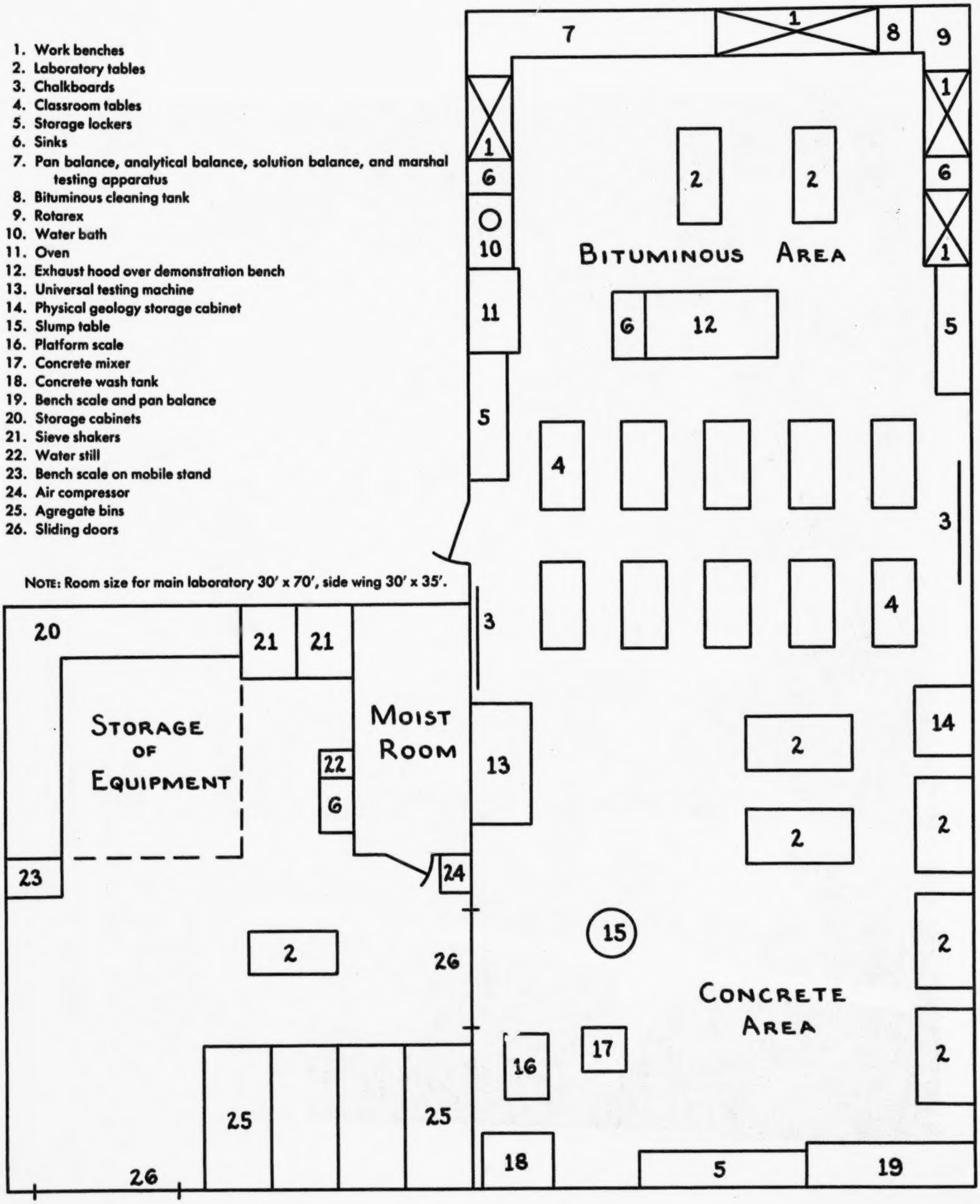
The front of each room should have a large table on which the instructor may display materials used in demonstrations. The floor should be of a material restful to the feet. The lighting should not be entirely natural, and it is recommended that the artificial lighting should be of a minimum of 50 candle-power at drawing board level. If fluorescent lighting is used, care should be taken that it does not give polarized light.

As may be seen from the equipment list shown under "Basic Laboratory Equipment and Supplies", the drafting room should contain all the equipment and aids that one would expect to find in an employment situation. In this room the student is expected to acquire some of the marketable skills required for any entry job. The equipment should be of modern design so that, upon completion of the training period, the student will be able to assume a position in industry with the minimum adjustment of his basic drafting skills.

Highway Materials Laboratory

The laboratory facilities for the courses which cover instruction in soils, portland cement, concrete, and bituminous materials are the most elaborate required in this program. One example of a layout for the laboratory is figure 7, which shows general arrangement of space and major items of equipment. Lists of required equipment are shown under "Highway Materials Laboratory Equipment and Supplies."

The classroom area in the center of the laboratory provides a lecture, demonstration, and computation area which, it is anticipated, would be relatively permanent. The bituminous area at the top of figure 7 and the concrete area at the bottom are shown as they might look when each of these materials is being studied during the course. The slump table, concrete mixer, and flatform scales would be placed in the storageroom when not in use, and the five 3′ by 6′ laboratory tables would be placed at convenient locations in the concrete area. These tables would be utilized for many of the soil mechanics tests. The laboratory mixers, automatic tapers, and mobile bench scale may be brought into the laboratory from the storage area and placed in appropriate work centers as they are required for studying bituminous materials. The bituminous area may also be used for some of the soil mechanics tests. This type of laboratory arrangement provides considerable flexibility and


7
1
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11
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1
5
2
2
Bituminous Area
6
12
4
3
3
4
20
21
21
Storage of Equipment
Moist Room
22
6
13
14
2
2
2
2
2
23
24
15
26
Concrete Area
16
17
25
25
18
5
19
26

1. Work benches
2. Laboratory tables
3. Chalkboards
4. Classroom tables
5. Storage lockers
6. Sinks
7. Pan balance, analytical balance, solution balance, and marshal testing apparatus
8. Bituminous cleaning tank
9. Rotarex
10. Water bath
11. Oven
12. Exhaust hood over demonstration bench
13. Universal testing machine
14. Physical geology storage cabinet
15. Slump table
16. Platform scale
17. Concrete mixer
18. Concrete wash tank
19. Bench scale and pan balance
20. Storage cabinets
21. Sieve shakers
22. Water still
23. Bench scale on mobile stand
24. Air compressor
25. Agregate bins
26. Sliding doors

Note: Room size for main laboratory 30′ x 70′, side wing 30′ x 35′.

Figure 7.—A suggested layout for a highway materials laboratory for studying soil mechanics, portland cement concrete, and bituminous material.

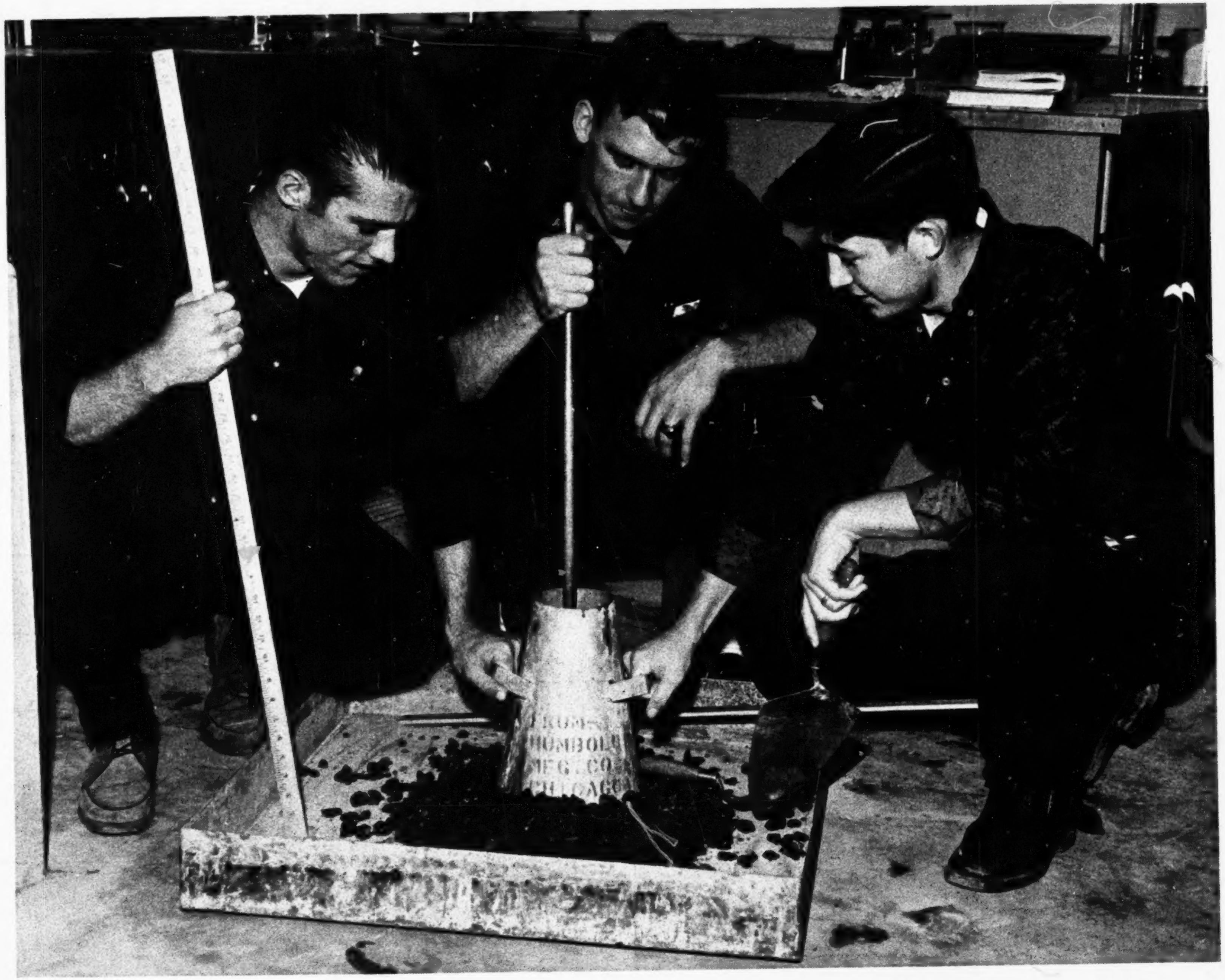


Figure 8.—Laboratory study of highway materials should include the performance of such standard tests of materials as the slump test for concrete, the simple equipment for which is here shown being used.

requires a minimum of space for adequate laboratories for the study of soils and materials.

The concrete test specimen curing room should be located adjacent to the engineering-materials laboratory. This room must be constructed to permit the maintenance of a constant temperature and controlled humidity. The humidity is usually held at a high relative level, so special attention to the construction of the walls must be given since condensed water will form on the inside and will seep or soak through most types of walls. A solid cast concrete wall construction with suitable waterproof paint on the inside is suggested. The room should be equipped with an automatic recording thermostatic temperature controller and a recording automatic humidity controller.

The equipment required for the engineering materials laboratory is listed below, together with its estimated cost. Additional desirable (but not absolutely necessary) equipment for this laboratory is listed separately. It is recommended that these desirable items of equipment be acquired as financial resources permit. If they can be purchased at the beginning of the program it may be desirable to consider placing the 120,000-pound-capacity universal testing machine in this laboratory where its capacity is needed for testing the compressive strength of concrete specimens, and acquiring a smaller universal testing machine (perhaps 60,000 pounds) for the strength-of-materials laboratory.

Strength-of-Materials Laboratory

The student's experiences in the strength-of-materials laboratory provides technical knowledge basic to engineering design. Such knowledge includes familiarity with current industrial equipment, procedures, and practices. For programs educating technicians, it is necessary to have adequate equipment with which to demonstrate and to teach basic scientific principles. Sufficient laboratory work stations should be provided to enable each student to use each piece of equipment. If only one universal testing machine is available it is recommended that it be located in the strength of materials laboratory as shown in figure 9, rather than in the engineering materials laboratory. This permits its use for strength-of-materials course students, and it may also be used by the engineering-materials class for compression testing of standard concrete test specimens as needed. For this reason, it is desirable to locate the strength-of-materials laboratory near the engineering-materials laboratory if possible.

The equipment recommended for a strength-of-materials laboratory is listed, with its estimated cost, in the laboratory equipment section.

Hydraulics, Hydrology and Drainage Laboratory

The laboratory for the Drainage and Geology course should be designed to teach the important principles of manometry; fluid flow in piping systems, overweirs in channels with uniform flow and backwater, and in channels, hydraulic, and energy gradients; and subsurface drainage.

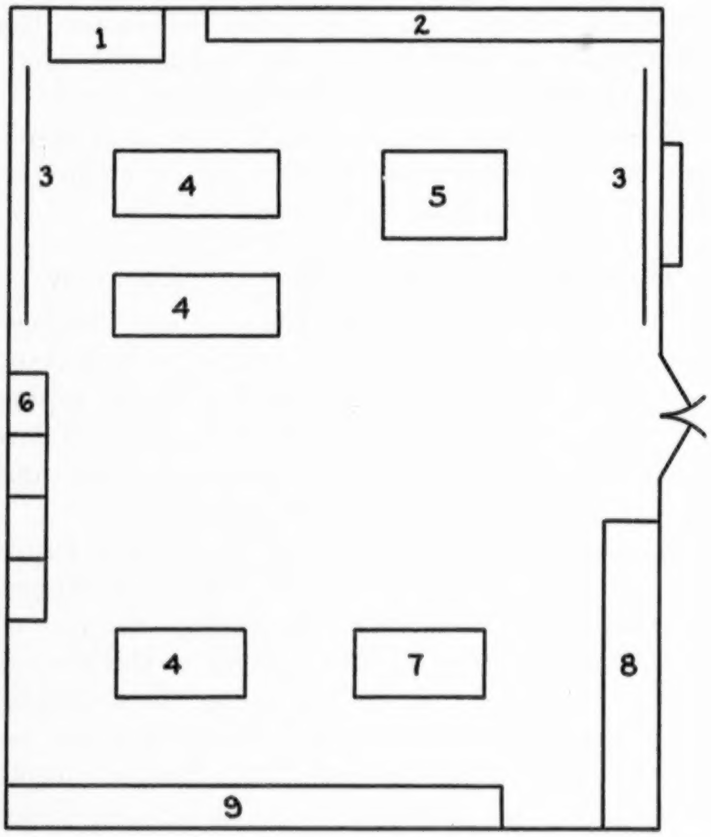
A plan for such a laboratory is shown in figure 11. It provides for a room 20′ by 35′, equipped with a station for demonstrating models of culverts, flumes, weirs, and bridges; a blackboard for the lecturer; and 15 worktables for students.

In the adjoining room are the apparatus for demonstrating and studying fluid flow by means of an open-channel flume with adjustable slope; three manometry study stations; a subsurface drainage tank; a hydraulic and energy gradient apparatus; an apparatus for studying fluid flow in pipes and over a weir; chairs for 15 students, a blackboard and an instructor's table.

Diagrammatic details of an apparatus for studying fluid flow in pipes are given in figure 12, and a picture is shown in figure 13. The apparatus is self-contained and permits circulation of fluid by pumping it through the system with variations in conditions obtained by using only parts of the piping system and various types and sizes of pipe and valves, permitting measurement of variations in flow with each varying set of conditions.

The hydraulic and gradient apparatus, the open channel-flume apparatus, and the demonstration equipment for culvert and bridges should be designed with self-contained pumping equipment, volumetric or gravimetric tanks, water supply, and measuring apparatus. Similarly, the subsurface drainage apparatus should be designed with an outflow tank beneath it so the outflow can be measured gravimetrically or volumetrically. It is suggested that a floor drain be installed in this laboratory to permit gravimetric drainage of water from the various pieces of laboratory equipment.

The items of equipment required for this laboratory are listed below.



1. Fatigue testing unit
2. Work bench
3. Chalkboards
4. Work tables
5. Torsion testing unit
6. Storage cabinets
7. Universal testing machine
8. Specimen storage
9. Hardness testing machines

NOTE: Room Size 32′ x 40′.

Electrical outlets should be supplied at approximately 10′ intervals.

Figure 9.—A suggested layout for a strength-of-materials laboratory.

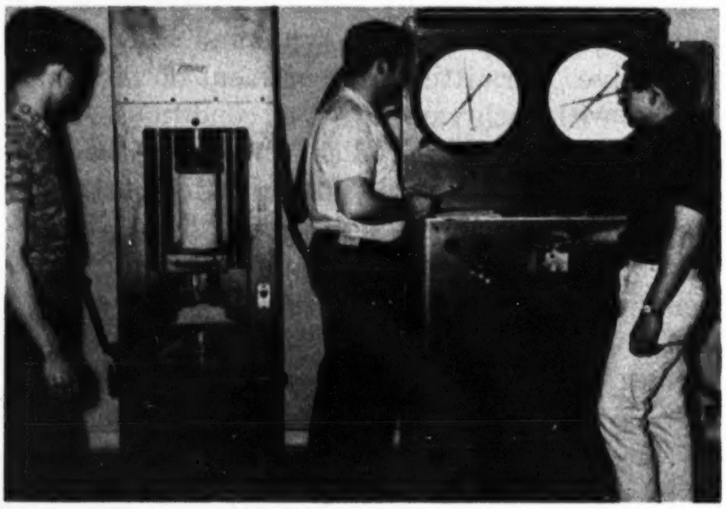


Figure 10.—This universal testing machine is an example of the necessary equipment for studying strength of materials. For educating highway or structural technicians the machine must have the capacity to perform the crushing (compression) strength test for standard concrete specimens, as shown here.

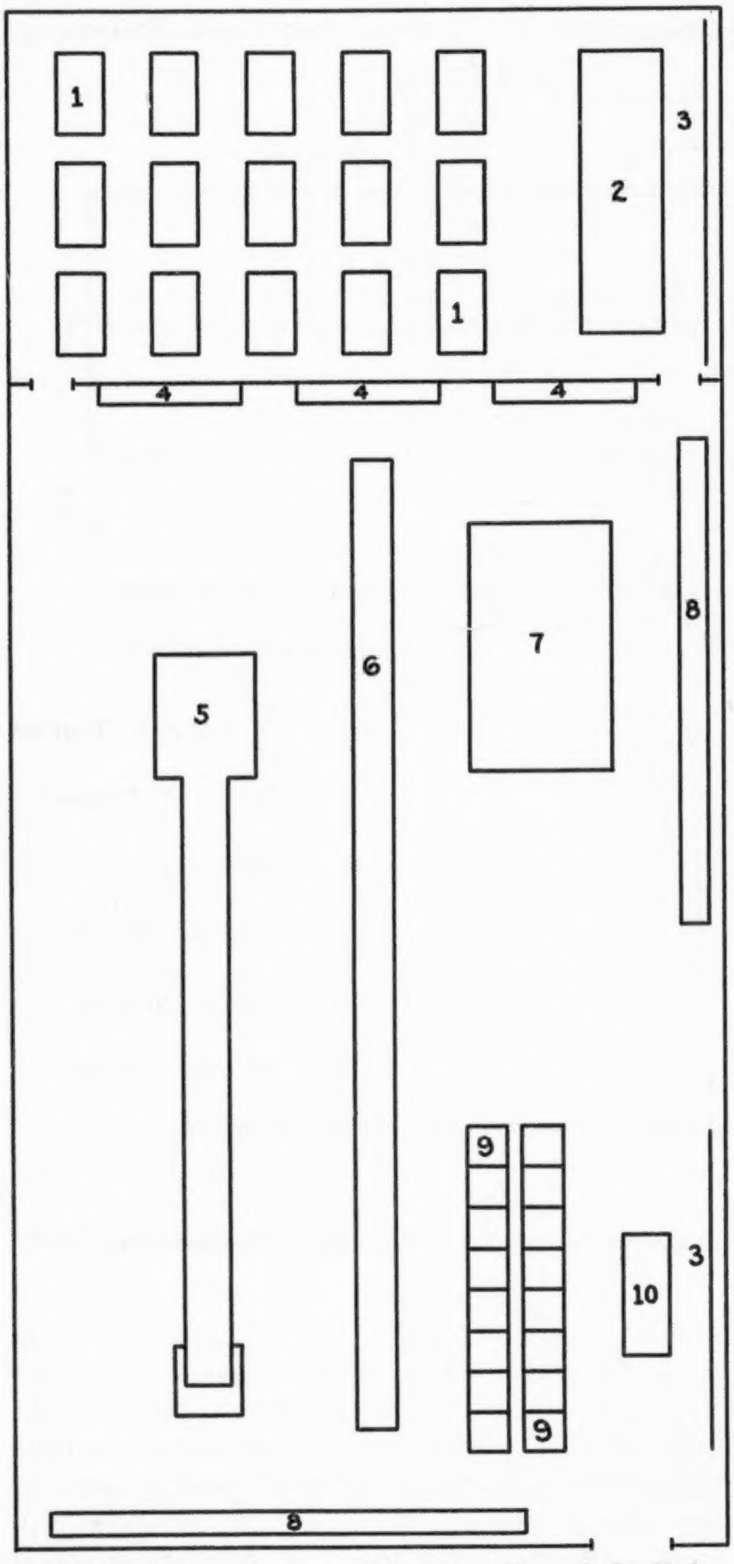
BASIC LABORATORY EQUIPMENT AND SUPPLIES

Building and equipping adequate laboratories for teaching civil technology is expensive. It may be feasible to build laboratories and install permanent work stations and the necessary apparatus to provide the minimum of laboratory equipment required to begin the teaching program. This allows the program to be started with a minimum outlay of funds, and permits the cost of additional desirable equipment to be spread over a period of time, during which laboratory equipment may be brought up to the level of a well-equipped facility.

The cost of establishing, equipping, and operating a department for teaching civil technology will be found to vary somewhat depending upon whether it is near to or far from major suppliers, the size of the department, the quality and the quantity of equipment or supplies purchased at a given time, and the method of purchasing. If the purchases can be made as part of a large purchase of scientific equipment through a central purchasing agency, the total price of civil technology equipment and supplies may be somewhat less than if the items are purchased separately. Small purchases of scientific and engineering equipment or supplies usually are not subject to the supplier's discounts as are purchases of larger quantities.

When plans to establish, enlarge, or re-equip a civil technology department progress to the point where a detailed and precise estimate of costs is required, it is suggested that the services of major suppliers be obtained so that cost estimates may be complete and sufficiently accurate for current budgetary purposes. Prior to a major purchase of equipment, a thorough investigation of the potential suppliers should be made by the department head or instructor, because in civil technology, as in other technologies, major changes are constantly taking place in the manufacture and supply of educational, industrial, and scientific equipment. The purchase of up-to-date equipment of good quality is an important factor in a successful teaching program for civil technology.

Experience has shown that the department head or instructor should make final decisions on the choice of laboratory equipment because of his knowledge of technical details. The instructor



1. Student work tables
2. Demonstration model for culvert and bridge studies
3. Chalkboard
4. Manometry units
5. Open channel flume with adjustable slope
6. Fluid flow unit
7. Subsurface drainage tank
8. Hydraulic and energy gradient
9. Student chairs
10. Table

NOTE: Room size 35' x 90', divided to make a room 35' x 20', and one 35' x 70'.

Figure 11.—A suggested layout for a hydraulics, hydrology, and drainage laboratory.

can avoid costly mistakes which often result if nontechnical personnel attempt to equip a scientific laboratory.

Surplus equipment, from either private or public organizations, can be an important source of good materials and hardware for equipping laboratories. Government surplus property may often be an especially attractive source of either standard or specialized components, units, assemblies, mechanisms, instruments, and systems, the cost of which usually is only a small fraction of the cost when new. Educational institutions are high on the priority list of agencies to which Government surplus property is made available.

Distribution of surplus property within the States must be made through State agencies for surplus property. Most such State agencies maintain one or more distribution centers at which authorized representatives of eligible schools or school systems select materials for educational use. Usually one or more officials of a school or school system are designated as authorized representatives. Technical educators should communicate with their authorized school or school system representative, if one exists, to arrange to visit their State agency's distribution center or write to the Director of their State agency for surplus property to obtain information regarding the procedures to be followed in acquiring equipment.[1]

The State director of vocational and technical education in each State can provide specific information on the location of the Government surplus property distributing agency in his State, and the persons in charge. Information on Government surplus property may also be obtained by writing to:

Chief, Surplus Property Utilization Division
U.S. Department of Health, Education, and
Welfare
Washington, D.C., 20201

Experience has shown that it is important to exercise the same elements of judgment and care in acquiring surplus equipment as are used in buying new equipment. Specific plans for the use, and sound justification for the need,

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[1] See publications listed in bibliography under U.S. Department of Health, Education, and Welfare, Office of Field Administration.

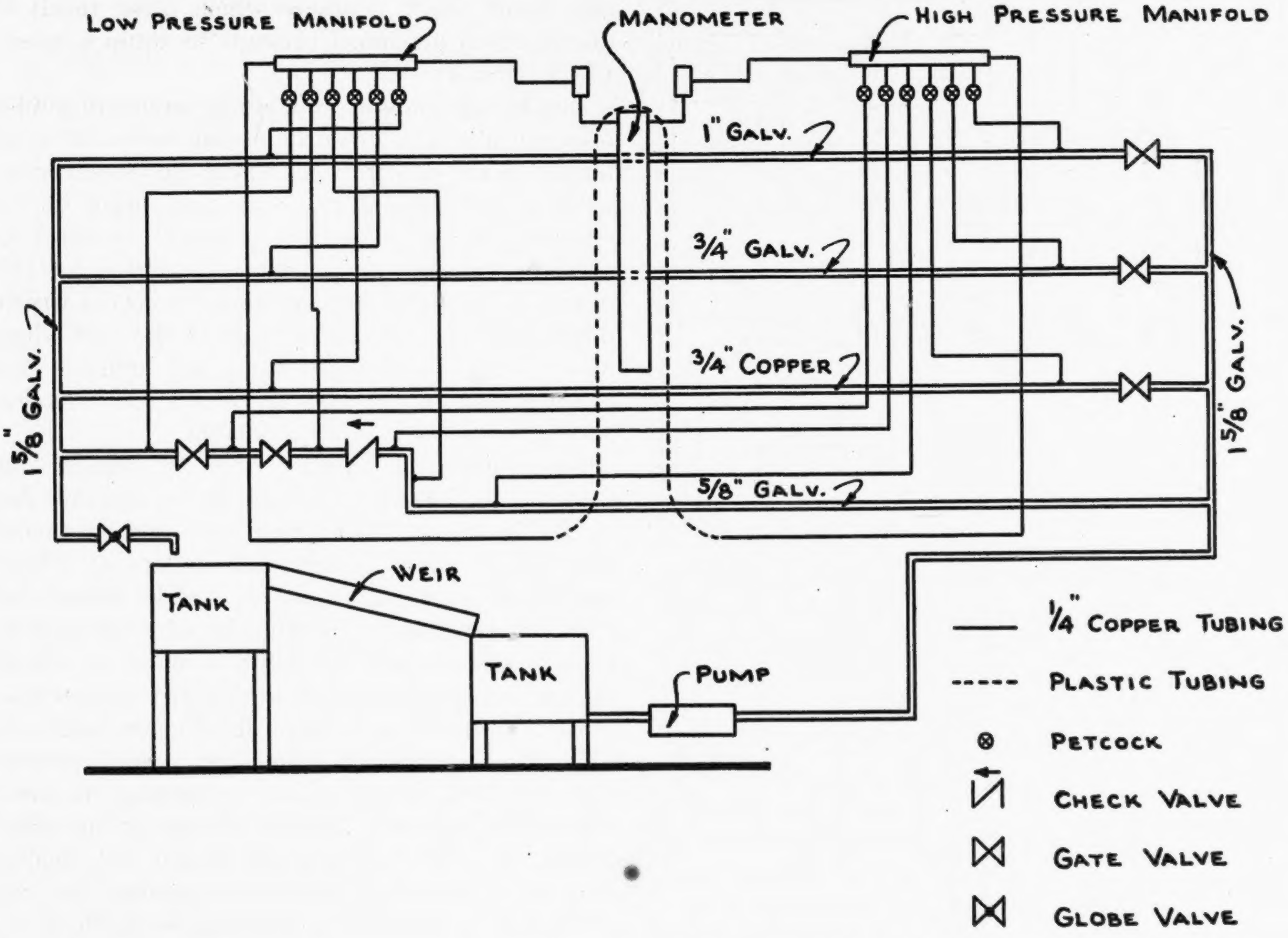
LOW PRESSURE MANIFOLD
MANOMETER
HIGH PRESSURE MANIFOLD
1" GALV.
3/4" GALV.
3/4" COPPER
5/8" GALV.
1 5/8" GALV.
1 5/8" GALV.
WEIR
TANK
TANK
PUMP
1/4" COPPER TUBING
PLASTIC TUBING
PETCOCK
CHECK VALVE
GATE VALVE
GLOBE VALVE

Figure 12.—Flow diagram for a fluid flow unit for a hydraulics, hydrology, and drainage laboratory.

should be established clearly for any price of surplus equipment. A careful analysis should be made of its total effectiveness in the program; its cost, including initial cost, transportation, space required, cost of installation, repair or tuneup (if incomplete), and maintenance; and its pertinence in terms of obsolescence.

Only technically competent, responsible, and imaginative persons should select surplus equipment, and then only after a thorough on-site inspection. This practice avoids the temptation or tendency to acquire equipment that is attractive but obsolete, irrelevant, bulky, or in excessive amounts. With these precautions in mind, resourceful department heads or instructors can usually obtain testing instruments, apparatus, and other essential up-to-date equipment for their laboratories at very reasonable cost.

Assumptions Made in the Following Estimated Costs

The following estimates are based on the cost of completely supplying and equipping a good civil technology department for teaching 24 highway and/or structural technician students at the date of this publication. They cover modern equipment and supplies of good quality, but not the most expensive. They do not include equipment or facilities for teaching auxiliary drafting or materials courses for other than civil technology.

The estimates assume the availability of a building of suitable construction, equipped with normal services, such as electricity, heat, and water, to and from the building, but otherwise unfurnished. The cost estimates include piping, wiring, plumbing, and other distribution of services within each facility described.

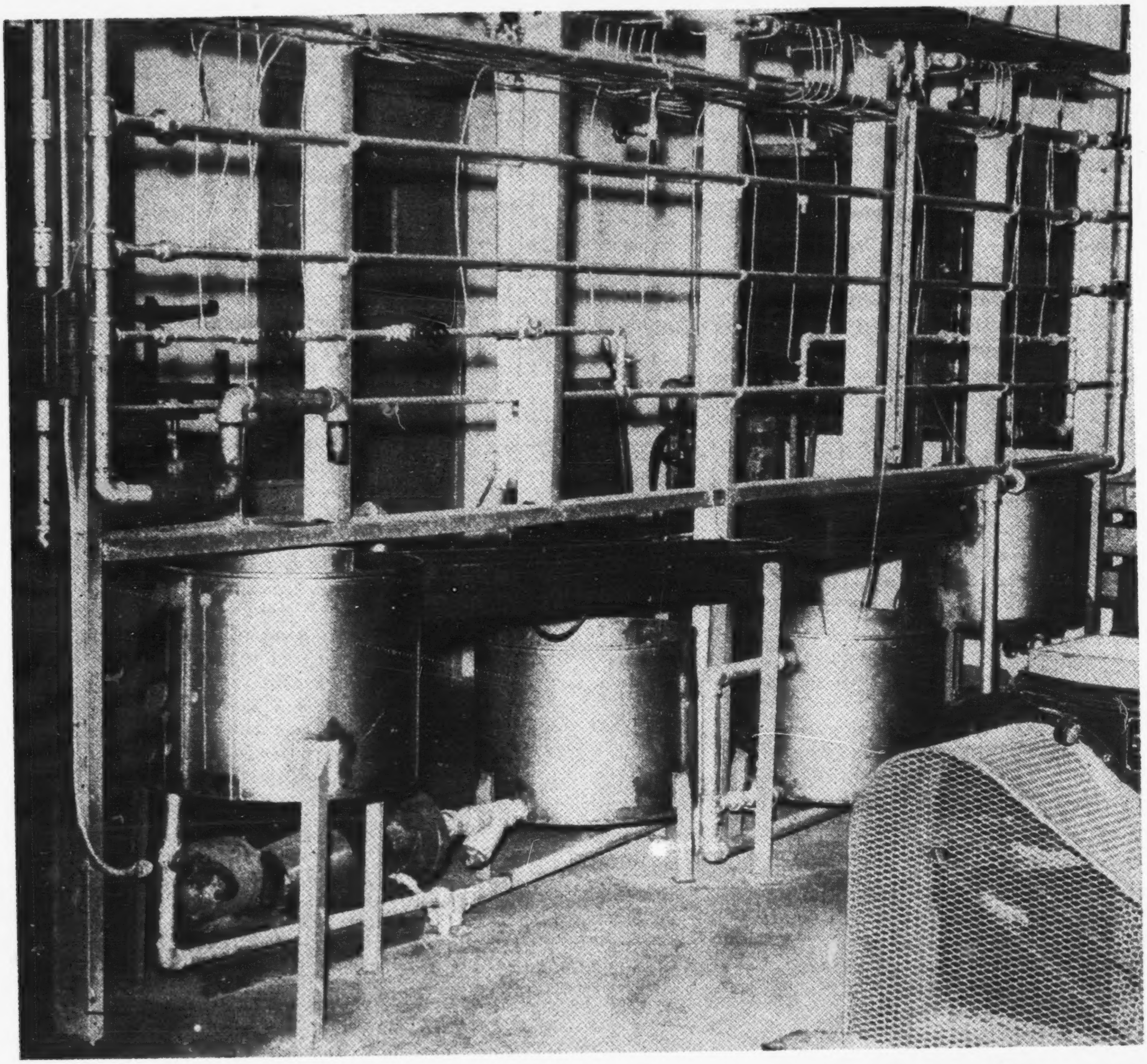

Figure 13.—Fluid flow apparatus for hydraulics, hydrology, and drainage laboratory. Two units, such as are shown in figure 12, set side-by-side provide experimental work stations for two teams of students.

No provision is made in this estimate for office furniture, conventional classroom blackboards, student seats, filing cabinets, and the conventional staff or instructor's office equipment. Neither the firefighting equipment commonly used in school buildings nor the special firefighting equipment required for a materials laboratory is listed because of the need for its being in accordance with local laws and ordinances.

The estimates for well-equipped laboratories having the furnishings and equipment described in the diagrams are listed hereunder for each facility. These facilities may be considered typical of those required for a good civil technology program. Facilities for any given institution may be expected to vary in detail, but should include most of the facilities and equipment here described.

Major items of equipment required for each laboratory are listed and an estimate of their cost is given as a gross figure with a range of estimated cost. Individual items are not priced for the reason that there may be substantial differences in the cost of comparable equipment and services in various locations. The same procedure and policy has been followed for listing and costing supplies suggested for each laboratory.

Drafting Laboratory Equipment and Supplies

Quantity	*Description*
12	Drafting tables—3′ by 4′; parallel ruling unit; metal based; dust cover.
12	Drafting tables—3′ by 5′; metal based; dust cover.
12	Drafting machines—24″ arms with assorted scales (at least two different makes).
24	Drafting stools.
1	Reproduction machine.
2	Blueprint filing cabinets—5 drawers with base and cap 30″ by 42″.
2	Filing cabinets for teachers.
1	Overhead projector.
24	Sets of drawing instruments and limited numbers of auxiliary items such as beam compasses.
1	Demonstrator slide rule—7′.
6	Assorted slide rules to demonstrate types used in industry.
24	Triangular architect's scales.
24	Triangular engineer's scales.
24	Triangular mechanical engineer's scales.
24	Flat scales—assorted.
24	Sets of triangles.
24	T-squares.
24	Protractors.
2 sets	Assorted curves and templates.
1	Cutting board.
4	Lettering guide sets.
1	Electric erasing machine.
24	Bench brushes.
2	Trimming shears—12″.
1	Overhead projector and screen.
1	35 mm. sound film projector.
1	16 mm. sound film projector.
	Engineering, machinists, standards, testing handbooks and other reference books.
	Supplies—Description.
	Tracing paper.
	Drawing paper.
	Tracing cloth.
	Reproduction paper and supplies.
	Assorted graph paper, orthographic, isometric and oblique sketching paper and pads, coordinate sheets, lettering guide sheets, etc.
	Pencils, erasers, erasing shields, thumbtacks, masking tape, ink, etc.

Estimated cost of drafting laboratory equipment and supplies, $10,000 to $12,000.

Surveying, Measurement, and Photogrammetry

Surveying and Measurement Field Equipment and Supplies

Quantity	*Description*
12	Steel tapes, 100′, surveyor's.
12	Chaining pins, 11/set.
24	Range poles.
12	Metallic tape, 50′.
24	Plumb bobs.
12	Hand axes.
12	Spring-tension balances for taping.
24	Clamp handles, for taping.
12	Dumpy levels.
12	Philadelphia level rods, extension type with target.
12	Hand levels.
8	Transits, vernier reading to 1 min.
8	Stadia boards, 10′ long.
8	Planetables, Johnson type.
8	Alidades, telescopic.
2	Tellurometers.
12	Mirror stereoscopes (Government surplus suggested).
12	Parallax bars (Government surplus suggested).
3	Theodolites, optical, reading to nearest second of arc, estimation to nearest tenth of second.
6	Tripods.
3	Subtense bars @ $425 each.
3	Self-leveling levels with stadia crosshairs.
3	USGS yard-type level rods.
6	Surveying altimeters.

Estimated cost, $27,000 to $30,000.

Surveying and Measurement Laboratory Equipment and Supplies

Quantity	*Description*
24	Drafting tables, 3′ by 5′, parallel ruling unit, metal based, dust cover.
24	Drafting stools.
2	Map filing cabinets, 5 drawers with base and cap, 30″ by 42″.
2	4-drawer filing cabinets, for teachers.
12	Planimeters, polar, optical.
12	Semicircular metal protractors, 8″ diameter, reading to ½°.
4	Desk calculators, electric.
1	Demonstrator slide rule, 7′.
	Assorted reference books.

Estimated cost, $8,500 to $9,500.

Photogrammetry Equipment and Supplies

Quantity	*Description*
24	Lens-type (pocket folding) stereoscopes.
24	Height finders (parallax bars to fit stereoscopes).
4	Stereocomparagraphs.

Quantity	*Description*
24	Enlargements, either 1″=50′, 1″=100′, 1″=200′, or 1″=400′, depending on tract density, for tax maps, 1 per student.
24	USGS quadrangle maps.

Estimated cost $4,000 to $4,500.

Photogrammetry Field Supplies

Stakes, 1″ by 2″ by 18″ and 1″ by 2″ by 36″.
Lath, 5′ lengths.
Boards, 1″ by 4″ by 48″.
Cloth, red and white, signal.
Kiel, crayon, string.

Photogrammetry Laboratory Supplies

	Map and planetable paper; cross-section, profile, coordinate, and ee papers; chalk, white and colored.
	USGS maps for school area.
72	9″ by 9″ aerial photos with 60% forward overlap, 3 per student. (Expendable—will need new photos for each class.)
300	±9″ by 9″ contact prints for mosaics (non-reusable).

Estimated cost, $500 to $1,000.

Total estimated cost for surveying, measurement and photogrammetry field and laboratory equipment, and supplies, $40,000 to $45,000.

Highway Materials Laboratory Equipment and Supplies

General Laboratory Equipment

Quantity	*Description*
2	Direct reading scales, scoop-type pan, bench type, capacity 5,000 g., direct reading to 500 g. at 1 g. interval, with weights.
2	Analytical balances, chainomatic, capacity 200 g., sensitivity 0.1 mg., with weights.
1	Direct reading scale, platform type, portable, capacity 200 lb., direct reading to 125 lb. at 0.1 lb. intervals.
2	Laboratory balances, 2 pan, capacity 2,000 g., sensitivity 0.05 g., with weight set 1 to 1,000 g.
1	Solution balance, capacity 20 kg, sensitivity 1 g.
10	Triple-beam balances, capacity 200 g., sensitivity 0.1 g.
1	Drying oven, thermostatically controlled to +1° C., max. temp. 270° C., interior dimensions 37″ by 19″ by 25″.
1	Air compressor, with 30 gal. tank, 75 psi gauge.
1	Vacuum-pressure pump, min. 0.01 mm. hg.
1	Automatic sieve shaker for 8″ diameter sieves.
2	Testing sieves, series, 8″, No. 4 to No. 200 (12 sieves/set).
1	Sieve shaker, aggregate, Gilson, with 7 sievers 2″ to No. 4.
2	Laboratory mixers—Lancaster PC with muller wheel with 3 mixing pans per mixer.
1	Automatic water still, capacity 3 gal./hour.
1	Aggregate bin, steel, 4 compartment, 8½′ by 17′ capacity 20 tons.
1	Moist room spray equipment plus air and water connection.
1	Water bath, thermostatically controlled to +1° C., max. temp. 100° C., 12″ diam., 12″ ht.
1	Eureka testing outfit (Dunegan buoyancy apparatus).
1	Laboratory truck, platform 28″ by 48″, 4 wheeled, rubber tired.
1	Waste cart, capacity, approx. 8 cubic ft.
10	Tables, wood, classroom, finished top 30″ by 60″, 30″ ht.
20	Stools, wood, 18″ ht.
	Storage cabinets and shelves, wood, built in under lab benches. Build as required.
8	Tables, laboratory, wood 36″ by 72″, 36″ ht.
300 ft	Tubing, saran, rubber and copper, asst. sizes.
1	Electric wall clock.
1	Desiccator, 200-mm. diameter with plate.
15	Battery syringes.
6	Beakers, aluminum, 500 ml.
3	Dial indicators (extensometers), 0.0001″ div.
3	Dial indicators (extensometers), 0.001″ div.
1	Mortar and pestle.
	Miscellaneous laboratory glassware including graduated cylinders, beakers, Erlenmeyer flasks, etc.
8	Equipment stands, steel, mobile, 4 wheeled, rubber tired.

Estimated cost of general laboratory equipment. $12,000 to $14,000.

Soils Laboratory Equipment

Quantity	*Description*
15	Specific gravity bottles, 50 ml.
15	Volumetric flasks, 500 ml.
2	Soil dispersion mixers, ASTM.
15	Thermometers, student grade, −10° to 110° C.
10	Liquid limit devices, ASTM.
15	Plates, safety glass, 15″ by 15″, for mixing soil.
9 doz	Ointment cans, tin, 3-oz. moisture content.
10	Burets, student grade, 50 ml.
40	Shrinkage dishes, porcelain.
20	Evaporating dishes, porcelain, 185 mm.
6	Crystallizing dishes, glass.
6	Pronged plates, shrinkage.
20	Spatulas, steel, 4″ blade.
20	Spatulas, steel, 6″ blade.
1	Sieve, No. 200, 8″ full ht., for washing soil.
10	Hydrometers, soil, ASTM.
10	Jars, hydrometer, 1,000 ml., ASTM.

Quantity	*Description*
10	Clocks, seconds (Kodak timers).
2	Automatic tampers, manual, 12" to 18" drop.
6	Molds, compaction, 1/30 cf., 4" ID with collars.
2	Mold bases, compaction, 10" diameter.
2	Tamping heads, 4" diameter with 4.5-lb. supplemental weight and mold collars.
10	Pans, aluminum, 17" by 25" by 1".
1	Ejector, compaction mold.
1	Sand-funnel apparatus and std. sand, for field density.
1	Rubber-balloon volumeter, for field density.
10	Spoons, sampling, 12" and small scoops.
1	Geologist pick.
10	Permeameters, plastic.
1	Soil sampling kit, hand sampling, Acker.
1	Consolidation loading frame and head, tabletop model.
1	Calibrated set of weights, for consolidation.
1	Set of consolidometer rings, accessories and sample preparation materials.
2	Unconfined compression apparatus for soils, dynamometer ring type.
2	Harvard miniature compaction apparatus.
1	Triaxial test chamber, 2.5" to 4.0" specimens, complete.
1	Set of triaxial testing accessories, including compaction mold, dynamometer ring, pressure regulator, and gage.
	Miscellaneous small equipment.

Estimated cost of soils laboratory equipment, $5,000 to $6,000.

Portland Cement Concrete Laboratory Equipment

Quantity	*Description*
1	Concrete mixer (4 ft^3).
1	Concrete internal vibrator.
1	Third-point loading device for flexural strength.
1	Vicat apparatus, plus one additional mold and needle.
1	30" flow table including 6¾" by 10" and 2¾" by 4" flow molds.
1	Flow caliper.
2	Hard-rubber tampers
3	Cement cube molds (gang of 3)
9	2" by 4" cement cylinder molds.
4	LeChatelier flasks.
4	Chapman flasks.
1	Organic-impurities-in-sand device.
1	Quality-of-water test set.
1	$\frac{1}{10}$ ft^3 unit weight measure.
1	½ ft^3 unit weight measure.
3	Tamping rods (24" long).
8 doz.	6" by 12" cardboard cylinder molds.
3	6" by 12" by ¼" thick wall metal cylinder and base plates.
1	Slump test set, including an extra slump cone.
1	Capping set (vertical, includes vertical capper, capping ladle, capping compound warmer, 100 lbs. capping compound, and cylinder carrier).
1	6" by 6" by 24" beam box.
1	6" by 6" by 36" beam box.
2	Concrete pans, 20" by 30" by 6".
3	Pails, galvanized (3½ gal.).
3	Shovels.
1	Conical mold and tamper for determining S.S.D. of fine aggregate.
1	Pycnometer top.
	Miscellaneous small equipment.

Estimated cost of portland cement concrete laboratory equipment, $2,000 to $3,000.

Bituminous Materials Laboratory Equipment

Quantity	*Description*
2	Penetrometers, portable model, ASTM.
4	Penetrometer needles, ASTM.
1	Transfer dish (for use with penetrometer).
9	Crucibles, Gooch, bitumen, porcelain.
9	Crucible adapters, glass (filter tube, for holding Gooch crucible).
3 ft	Rubber tubing (to hold crucible in adapter).
9	Filtering flasks with side tube, 1,000 ml.
5	Viscosimeters, Saybolt Furol, single tube, ASTM–D88, with tube and pan.
10	Receiver flasks, Saybolt viscosity, ASTM, 60 ml.
5	Thermometers, Saybolt viscosity, ASTM, 19° to 27° C.
5	Thermometers, Saybolt viscosity, ASTM, 49° to 57° C.
5	Thermometers, Saybolt viscosity, ASTM, 57° to 65° C.
5	Thermometers, Saybolt viscosity, ASTM, 79° to 87° C.
2	Viscosimeter pipets, with aspirator bulb.
5	Viscosimeter tube cleaners.
12	Flasks, distillation, church, with side neck, ASTM, pyrex, 500 ml.
9	Condenser tubes, 250-mm. standard ASTM, glass jacketed.
9	Adapters, curved, for distillation.
5	Shields, 500-ml. size, ASTM, for distillation.
10	Graduated cylinders (receivers), ASTM–D402, 100 ml., 1 ml. division.
10	Thermometers, high distillation, ASTM, 0° to 400° C. in 1° divisions.
5	Flashpoint testers, Cleveland open cup, ASTM, complete with accessories.
4	Thermometers, armored, asphalt, 100° to 450° F., 5° divisions.
1	Capaction hammer, Marshall.
6	Compaction molds, Marshall, 4" diameter.
1	Compaction mold holder.

Quantity	*Description*
1	Marshall stability testing head with flow indicator.
1	Marshall stability loading frame.
1	Rotarex, bitumen separator, 1,000 gm., with variable-speed motor.
200	Filter paper rings for use with 1,000-gm. rotarex.
2 lbs	Rubber stoppers, various sizes.
5	Burner (Bunsen type).
1	Safety can for disposal of flammable liquids, 2 gal.
2	Safety wash cans for flammable liquids, 2 gal.
12	Wire gauze squares, iron with asbestos centers, 6″ by 6″.
12	Clamps, utility, asbestos.
12	Pans, metal, approx. 12″ by 12″ by 4″.
12	Pans, metal, round, 4 qt.
10 pr	Gloves, asbestos
24	Pencils, glass marking.
24	Aprons, laboratory.
2	Rings, cork (Suberite) 90mm. ID.
1 set	Cork borers, number in set, 9.
4	Aspirators (filter pump).
1	Hotplate, 9″.
	Cork stoppers, various sizes.
12	Glass stirring rods, 250mm. length.
10	Dishes, evaporating, porcelain, 250 ml.
4	Thermometers, general laboratory, −5° to 360° C. 1° division.
6	Specific gravity bottles (pycnometer) (Erlenmeyer form), pyrex, bitumen.
10	Support stands, apparatus, rectangular base, 24″ ht.
6	Rings, support, cast iron with clamps, 4″ outside diameter.
	Miscellaneous tools and small items.

Bituminous Materials Laboratory, Chemical Supplies

Quantity	*Description*
5 gal	Carbon tetrachloride (tech. grade).
5 lbs	Calcium chloride, tech. anhydrous, lump for desiccator.
5 gal	Benzene.
1 lb	Asbestos, long fiber (amphibole), gooch grade.
6 lbs	Mercury (tech. grade).
10 lbs	Sodium hexametaphosphate.
	Miscellaneous other chemical supplies.

Estimated cost of bituminous materials laboratory equipment and supplies, $3,500 to $4,000.

Additional Desirable Equipment for Highway Materials Laboratory

Quantity	*Description*
1	Ductility testing machine with molds.
5	Softening point apparatus, complete.
1	Air meter, concrete, ¼ c.f.
1	Cement autoclave, for soundness test, with accessory equipment.
1	Triaxial test control panel.
2	Consolidation loading frames with head, tabletop.
2	Consolidation weight sets.
2	Consolidation rings and accessories.
1	California bearing ratio, laboratory test set, except molds and loading press.
4	CBR compaction molds, 7″ ht., 6″ diameter.
2	Tamping heads, automatic tamper for 6″ mold.
1	Engler viscosimeter.
20	Jars, hydrometer, 1,000 ml., ASTM.
1	Universal testing machine, capacity 120,000 lbs. with attachments.

Estimated cost for additional desirable equipment for highway materials laboratory, $30,000 to $35,000.

Summary of Costs of Highway Materials Laboratory Equipment and Supplies

General laboratory equipment	$12,000	to	$14,000
Soils laboratory equipment	5,000	to	6,000
Portland cement concrete laboratory equipment	2,000	to	3,000
Bituminous materials laboratory equipment and supplies	3,500	to	4,000
	22,500	to	27,000
Additional desirable equipment for highway materials laboratory	$30,000	to	$35,000

Strength of Materials Laboratory

Quantity	*Description*
1	Universal Testing Machine, capacity 120,000 lbs., with attachments.
1	Brinell hardness testing machine.
4	Rockwell hardness testers.
1	Shore scleroscope harness tester
1	Impact testing machine.
1	Torsion testing machine.
1	Rotating beam fatigue machine.
1	Resistance strain indicator.
3	Worktables.
	Assorted strain gages.
	Accessories, tools and instruments.

Estimated cost, $32,000 to $36,000.

Hydraulics, Hydrology, and Drainage Laboratory Equipment

Quantity	*Description*
15	Drafting tables, 3′ by 5′, parallel ruling unit; metal based, dust cover.
15	Drafting stools.
1	Table for instructor.
1	Chair for instructor.

Quantity	*Description*
1	Rainfall and runoff equipment (current meter rain gage, stage recorder).
1	Culvert demonstration equipment (Lucite models, pump, weighing tank).
3	Manometry apparatus.
1	Hydraulic and energy gradients unit.
1	Fluid-flow measurement in pipes apparatus.
1	Uniform flow in open channels apparatus.
1	Subsurface drainage unit.
	Weighing equipment.
	Venturi measuring equipment.
	Assorted valves and pipefittings.
	Hand tools.
	Point gages, stopwatches, timing, clocks.
	Sieve equipment.
	Assorted pressure gages.

Estimated cost, $17,000 to $20,000.

SUMMARY OF COSTS

The listed equipment is basic and does not include items for specialized programs, which may be related but are not outlined here. In addition to the cost of basic equipment, a further sum of $5,500 to $10,000 should be earmarked and included in initial equipment cost estimates to cover the cost of installing equipment and built-in furnishings in the various laboratories. An initial fund of approximately $3,000 to $5,000 should be provided for the purchase of expendable materials and replacement parts.

Therefore, the total initial cost of equipment for a civil technology program to educate highway and structural technicians, based on prices in 1965, may be estimated as follows:

Laboratory facility	*Estimated cost*
Drafting laboratory equipment and supplies	$10,000 to $12,000
Surveying, measurement, and photogrammetry field and laboratory equipment, and supplies	40,000 to 45,000
Highway materials laboratory equipment (general, soils, portland cement concrete, and bituminous) and supplies; minimum, see below*	22,500 to 27,000
Strength-of-materials laboratory	32,000 to 36,000
Hydraulics, hydrology, and drainage laboratory	17,000 to 20,000
Installation of equipment and built-in furnishings	5,500 to 10,000
Expendable materials and replacement parts	3,000 to 5,000
Total estimated cost of laboratory equipment and supplies	$130,000 to $155,000
*Additional desirable equipment for highway materials laboratory	$30,000 to $35,000

The foregoing estimates do not provide for the cost of the building which, if constructed for the program, may be calculated at $12 to $14 per square foot of unfurnished laboratory space. Such space with special utilities and built-in furnishings, without portable equipment, may be estimated at $25 to $30 per square foot.

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APPENDIXES

APPENDIX A

SELECTED LIST OF SCIENTIFIC OR TECHNICAL SOCIETIES AND ASSOCIATIONS CONCERNED WITH CIVIL TECHNOLOGY

A list of some professional and technical societies and several trade organizations concerned with civil engineering and its application may be a helpful source of instructional information and reference data. Inclusion of an organization's name in the list which follows does not imply special approval of that organization, nor does omission imply disapproval. Details regarding local chapters or sections of societies have been omitted. Society descriptions and membership data reflect status in January 1965.

It is suggested that teachers and others desiring information from the organizations listed below address inquiries to the executive secretary of the group in which they are interested.

Professional or Technical Societies

American Association of State Highway Officials, 917 National Press Building, Washington, D.C., 20004

History: Founded 1914.

Purpose: To foster the development, operation, and maintenance of a nationwide integrated system of highways to serve adequately the transportation needs of the country.

Total Membership: 53 State Highway Departments. Full-time employees of a member department are termed active members.

Publications: American Highways, quarterly.

American Concrete Institute, P.O. Box 4754, Detroit, Mich., 48219.

History: Organized January 17, 1905; chartered December 14, 1906. Adopted present name July 2, 1913.

Purpose: To organize the efforts of its members for a nonprofit public service in gathering, correlating, and disseminating information for the improvement of the design, construction, manufacture, use, and maintenance of concrete products and structures.

Total Membership: 12,300.

Publications: Journal, monthly.

American Congress on Surveying and Mapping, 733 15th St. NW., Washington, D.C., 20005.

History: Organized June 1941.

Purpose: To advance the sciences of surveying and mapping in their several branches; to further the interests of both those who use maps and surveys and those who make them; to establish a central source of reference for its members; to contribute to public education in the use of maps and surveys, and to encourage the prosecution of basic mapping and surveying programs which are paid for in whole or in part with public funds; to provide a much needed means or channel for the exchange of information, advancement of techniques, establishment of standards, improvement of the professional status of those engaged in the work, and the exercise of international, national, and local expression on all matters concerning the general and scientific development of surveying and mapping.

Total Membership: 6,000.

Publications: ACSM Bulletin, published periodically.
Surveying and Mapping, quarterly.

American Institute of Architects, 1735 New York Ave. NW., Washington, D.C., 20006

History: Organized 1857.

Purpose: To organize and unite in fellowship the architects of the United States of America; to combine their efforts so as to promote the aesthetic, scientific, and practical efficiency of the profession; to advance the science and art of planning and building by advancing the standards of architectural education, training, and practice; to coordinate the building industry and the profession of architecture to insure the advancement of the living standards of our people through their improved environment; to make the profession of ever-increasing service to society.

Total Membership: 16,000.

Publications: Journal, monthly.
Memo (newsletter), biweekly.

American Iron and Steel Institute, 150 East 42d St., New York, N.Y., 10017

History: Founded in 1855 as the American Iron Association. Absorbed into American Iron and Steel Institute in 1864, and incorporated March 31, 1908.

Purpose: To promote the interests of the iron and steel industry; to collect and publish statistics and other information concerning any matters connected with the industry; to provide a forum for the exchange of information and discussion of problems relating to the industry; to engage in activities to promote the use of iron and steel.

Total Membership: 2,859.

Annual Statistical Report.
Publications: Steel Facts, bimonthly.
Steelways, bimonthly.
Yearbook (Directory of Iron and Steel Works of the United States and Canada) published triennially.

American Railway Bridge and Building Association, 220 South Michigan Ave., Chicago, Ill., 60604

History: Organized 1891 as Association of Railway Superintendents of Bridges and Buildings; name changed to present title in 1908.

Purpose: To bring together railroad men interested in the construction and maintenance of railroad bridges and buildings, and to advance their interests by increasing knowledge in this branch of engineering.

Total Membership: 900.

Publications: Irregular.

American Railway Engineering Association, 59 East Van Buren St., Chicago, Ill., 60605

History: Organized March 30, 1899 as the American Railway Engineering and Maintenance of Way Association; incorporated 1899; name changed to present title in 1912.

Purpose: To promote the advancement and dissemination of knowledge pertaining to the scientific and economic location, construction, maintenance, and operation of American railroads.

Total Membership: 3,450.

Publications: *Bulletin*, published seven times a year.
Manual of Recommended Practice; Portfolio of Truckwork Plans.
Proceedings, annual.

American Sanitary Engineering Intersociety Board, P.O. Box 2728, Washington, D.C., 20016

History: Incorporated 1955.

Purpose: To improve the practice, elevate the standards, and advance the cause of sanitary engineering; to grant and issue to engineers, duly licensed by law to practice engineering, certificates of special knowledge in the various fields of sanitary engineering.

Total Membership: 1,016.

Publications: *Sanitary Engineering Education Directory.*

American Society for Engineering Education, 1346 Connecticut Ave. NW., Washington, D.C., 20036

History: Organized 1893 as the Society for the Promotion of Engineering Education; merged with the Engineering College Research Association in June 1946 to form the present society.

Divisions:

Aeronautical
Architectural
Chemical
Civil
Cooperative Engineering Education
Educational Methods
Electrical
Engineering Economy
Engineering Graphics
English
Evening Engineering Education
Graduate Studies
Humanities and Social Sciences
Industrial
Mathematics
Mechanical
Mechanics
Mineral
Physics
Relations With Industry
Technical Institute

Purpose: The advancement of education in all its functions which pertain to engineering and allied branches of science and technology, including the processes of teaching and learning, research, and public relations.

Total Membership: 9,400.

Publications: *Journal of Engineering Education*, monthly October through June.

American Society for Testing Materials, 1916 Race St., Philadelphia, Pa.

History: Organized June 16, 1898, as the American Section of the International Association for Testing Materials; incorporated under present title March 1902.

Purpose: The promotion of knowledge of the materials of engineering, and the standardization of specifications and methods of testing.

Total Membership: 11,500.

Publications: *Materials, Research, and Standards,* monthly; supplements in intervening years.
Proceedings, annual.
Yearbook, distributed to members only.
Special technical publications, published irregularly.

American Society of Civil Engineers, 345 East 47th St., New York, N.Y., 10017

History: Instituted November 5, 1852, as the American Society of Engineers and Architects; inactive 1855–67; name changed to present title March 4, 1868; incorporated April 17, 1877. The society has 143 local sections and branches, an active associate member program, and 140 student chapters.

Technical Divisions:

Air Transport
City Planning
Construction
Engineering Mechanics
Highways
Hydraulics
Irrigation and Drainage
Pipeline
Power
Sanitary Engineering
Soil Mechanics and Foundations
Structural
Surveying and Mapping
Waterways

Purpose: To promote the advancement of the science and profession of engineering.

Total Membership: 53,540.

Publications: *Civil Engineering*, monthly.
Directory, annual.
Proceedings (journals of the Technical Divisions), published monthly.
Transactions, published annually.

American Society of Heating, Refrigerating, and Air-Conditioning Engineers, 234 Fifth Ave., New York, N.Y., 10017

History: The American Society of Heating and Air-Conditioning Engineers was organized in 1894 and incorporated in 1895 as the American Society of Heating and Air-Conditioning Engineers. The American Society of Refrigerating Engineers was organized in 1940. The two organizations merged to form the present society in January 1959.

Purpose: To advance the arts and sciences of heating, refrigeration, air-conditioning, and ventilation, and the allied arts and sciences for the benefit of the general public.

Total Membership: 17,606.

Publications: *ASHRAE Guide and Data Book*, annual.
Journal, monthly.

American Society of Photogrammetry, 644 Leesburg Pike, Falls Church, Va., 22044

History: Organized August 1934; incorporated October 1934.

Committees:

- Research
- Nomenclature
- Photo Interpretation
- Map Specification and Tests
- Professional Stature
- Geographic Exploration
- Aerial Photography
- Specifications for Highways
- Weather Research

Purpose: To advance knowledge in the science and art of photogrammetry; to provide means for the dissemination of new knowledge and information, and thus to encourage the free exchange of ideas and intercourse among those contributing to the advancement of the art; to stimulate student interest in the field of photogrammetry by advocating a strengthening of college curriculums; to hold meetings for the presentation of symposia, panels, papers, and discussions; to exert its efforts toward the improvement of standards and the betterment of ethics; to maintain the dignity of the profession; and to foster a spirit of understanding and cooperation among photogrammetrists in the United States and throughout the world.

Total Membership: 4,000.

Publications: *Manual of Photogrammetry* (textbook).
Manual of Photographic Interpretation (textbook).
Photogrammetric Engineering, quarterly.

American Society of Safety Engineers, 5 North Wabash Ave., Chicago, Ill., 60602

History: Organized 1911; present name adopted 1914; 82 chapters in the United States and Canada.

Purpose: To promote the arts and sciences in the prevention of accidents, and the conservation of life, health, and property; to attain a high standard in safety engineering and to encourage the development of safety engineering as a profession.

Total Membership: 7,000

Publications: *Journal of the American Society of Safety Engineers*, monthly.

American Society of Sanitary Engineering, 228 Standard Building, Cleveland, Ohio, 44113

History: Organized and incorporated 1906.

Purpose: Research in plumbing engineering, water supply, sewage disposal, and fixture design.

Total Membership: 2,400.

Publications: Intermittent.

American Water Works Association, 2 Park Ave., New York, N.Y., 10016

History: Organized 1881; incorporated 1912.

Purpose: Advancement of knowledge of design, construction, operation, and management of waterworks.

Total Membership: 16,700.

Publications: AWWA Journal, monthly.

American Welding Society, 33 West 39th St., New York, N.Y., 10017

History: Organized March 1919

Technical Committees:

- Symbols
- Definitions and Charts
- Filler Metal
- Safety Recommendations
- Methods of Inspection
- Standard Qualification Procedures
- Resistance Welding
- Metallizing
- Brazing and Soldering
- Building Codes
- Welded Bridges
- Marine Construction
- Field Welding of Storage Tanks
- Field Welding of Steel Water Pipe Joints
- Automotive Welding
- Welding Iron Castings
- Welding Concrete Reinforcing Steel
- Missiles and Rockets
- Railway Welding
- Piping and Tubing

Purpose: To advance the science and art of welding; to afford its members opportunities for the interchange of ideas with respect to welding and for the publication of information thereon; to sponsor or conduct welding research cooperating with other societies, associations, and governmental departments for the benefit of industry in general.

Total Membership: 15,500.

Publications: *Welding Journal*, monthly.
Welding Handbook.

Association of Asphalt Paving Technologists, 1224 East Engineering Building, University of Michigan, Ann Arbor, Mich., 48104

History: Organized 1924; incorporated 1959.

Purpose: To advance the technology of asphalt pavement construction, including production and testing of materials, and control of production, and laying of pavements; to encourage intercourse between men charged with technical responsibility; to exchange ideas related to technology of asphalt pavement.

Total Membership: 495.

Publications: *Proceedings*, annual.

Association of Iron and Steel Engineers, 1010 Empire Building, Pittsburgh, Pa, 15222.

History: Organized in 1907 as the Association of Iron and Steel Electrical Engineers; name changed August 1936 to present title.

Purpose: The advancement of the technical and engineering phases of the production and processing of iron and steel.

Total Membership: 10,000.

Publications: *Iron and Steel Engineer*, monthly.
Proceedings, annual.

Engineers' Council for Professional Development. 345 East 47th St., New York, N.Y., 10017

History: Organized October 3, 1932.

Purpose: To advance and promote scientific and engineering education with a view to the promotion of the public welfare through the development of better educated engineers.

Members: Eight engineering societies participate in the organization:

- American Institute of Chemical Engineers
- American Institute of Electrical Engineers
- American Institute of Mining, Metallurgical, and Petroleum Engineers
- American Society of Civil Engineers
- American Society for Engineering Education
- American Society of Mechanical Engineers
- Engineering Institute of Canada
- National Council of State Boards of Engineering Examiners

Publications: Annual Report.

Engineers Joint Council, 345 East 47th St., New York, N.Y., 10017

History: Created in 1941; changed to its present organizational structure in 1952.

Committees:

- Automation
- Engineering Manpower Commission
- Honors for Engineers
- International Relations
- National Transportation Policy Panel
- National Water Policy Panel
- Nuclear Congress
- Public Relations
- Recognition of Specialties
- Who's Who in Engineering, and others

Constituent Societies:

- American Institute of Chemical Engineers
- American Institute of Electrical Engineers
- American Institute of Industrial Engineers
- American Institute of Mining, Metallurgical, and Petroleum Engineers
- American Society of Civil Engineers
- American Society for Engineering Education
- American Society of Heating, Refrigerating and Air-Conditioning Engineers
- American Society of Mechanical Engineers
- American Water Works Association
- Society of American Military Engineers

Purpose: To advance the general welfare of mankind through the resources and creative abilities of the engineering profession, and pursuant thereto, to promote cooperation among the various branches of engineering.

Total Membership: 10 Constituent Societies with 300,000 members.

Publications: *Engineer*, quarterly.
Engineering Manpower Commission Newsletter, published semimonthly.
Annual Report.

Highway Research Board, 2101 Constitution Ave. NW., Washington, D.C., 20418

History: Organized 1920 as Advisory Board on Highway Research; name changed to present form in 1924.

Purpose: To encourage research and to provide a national clearinghouse and correlation service for research activities and information on highway administration transport and technology by means of: (1) A forum for presentation and discussion of research papers and reports; (2) committees to suggest and plan research work and to correlate and evaluate results; (3) dissemination of useful information; and (4) liaison and cooperative services.

Total Membership: 1,870.

Publications: *Proceedings*, annual.
Highway Research Abstracts, published monthly, except in August.
Yearbook, annual.
Research reports, bulletins, bibliographies, and special reports published at frequent irregular intervals.

Institute of Traffic Engineers, 1725 DeSales St. NW., Washington, D.C., 20036

History: Organized in 1930; incorporated in 1954.

Purpose: To advance the art and science of traffic engineering, and encourage intercourse between men with mutual interests in this work; to foster traffic engineering education; to stimulate original research in this field; to advance professional development of, and establish a central point of reference and union for, members.

Total Membership: 2,300.

Publications: *Traffic Engineering*, monthly.
Proceedings, annual.
Yearbook.

National Society of Professional Engineers, 2029 K St. NW., Washington, D.C., 20006

History: Founded in 1934.

Purpose: To promote the professional, social, and economic interests of the engineer by means of education, legislation, and public relations; to establish and maintain state professional engineering societies and chapters throughout the United States, and to advance the interests of the public in matters pertaining to engineering.

Total Membership: 52,000.

Publications: *American Engineer*, monthly.
Legislative Bulletin, monthly.
Engineering Employment Practices Newsletter, monthly.

Society of American Military Engineers, The Flemming Building, Washington, D.C., 20006

History: Organized 1919, incorporated in 1925.

Purpose: To promote the national defense by the advancement of knowledge of the science of military engineering; to increase the engineer potential of the nation for the national security.

Total Membership: 28,000.

Publications: Military Engineer, published bimonthly.

United States National Committee, International Commission on Irrigation and Drainage, P.O. Box 7826, Denver, Colo., 80215.

History: Organized 1952 under sponsorship of the Irrigation and Drainage Division of the American Society of Civil Engineers.

Purpose: To promote advances in the science of irrigation, drainage, and flood control.

Total Membership: 300.

Publications: Bulletin, annual.
Transactions, published triennially.

APPENDIX B

SAMPLE PROBLEMS

Sample Home Problem—Materials Course

1. In the stockpiles at a portland cement concrete batch plant, the following conditions exist:

Stockpile of sand—contains 6 percent coarse aggregate and 3 percent surface moisture
Stockpile of coarse aggregate—contains 5 percent sand and has 2 percent absorption (by S.S.D. weight)

Calculate the number of pounds of material needed from each stockpile to produce the following batch of concrete:

Size of batch = 34 ft.^{3} plus 10 percent overload
Mix by weight 1 : 2½ : 4
Water cement ratio = 5½ gal./sack
Total entrained air = 4 percent
Specific gravity of sand = 2.62
Specific gravity of coarse aggregate = 2.69
Specific gravity of cement—3.15

How many gallons of mixing water will be needed?

Sample Solution of Home Problem—Materials course

One bag batch:

$\frac{94}{3.15(62.4)} = 0.478$ ft.^{3} solid volume of cement
$\frac{2.5(94)}{2.62(62.4)} = 1.438$ ft.^{3} solid volume of sand
$\frac{4(94)}{2.69(62.4)} = 2.240$ ft.^{3} solid volume of coarse aggregate
$\frac{5.5}{7.48} = \frac{0.735 \text{ ft.}^3}{4{,}891 \text{ ft.}^3}$ of water
air free volume

Let X = 4% of the *actual* volume in ft.^{3}

$(4.891+X)0.04 = X$
$0.1955 + 0.04X = X$
$0.1955 = 0.96X$
$X = \frac{0.1955}{0.96} = 0.204$ ft.^{3}

Actual volume = 4.891 + 0.204 = 5.095, say 5.10 ft.^{3}

Another method is to let X = the actual volume.

$X - 4.891 = 0.04X$
$0.96X = 4.891$
$X = \frac{4.891}{0.96} = 5.095$, say 5.10 ft.^{3}

This latter method is more simple and more often used.

Volume of concrete needed = 34 + (0.10)34 = 37.4 ft.^{3}

Increase size of batch from one bag to $\frac{37.4}{5.10} = 7.33$ bags

Weights of materials:

94(7.33) = 689 lbs. of cement
94(2.5)(7.33) = 1,723 lbs. of S.S.D. sand
94(4)(7.33) = 2,758 lbs. of S.S.D. coarse aggregate
5.5(7.33) = 40.3 gal. of water

Let X = weight of material needed from sand stockpile

$X - 1{,}723 = 0.06X$
$1{,}723 = 0.94X$
$X = \frac{1{,}723}{0.94} = 1{,}833$ lbs.

Amount of pebbles in the sand = 1,833 − 1,723 = 110 lbs.

Let X = weight of material needed from coarse aggregate stockpile

$X - 2{,}758 = 0.05X$
$2{,}758 = 0.95X$
$X = \frac{2{,}758}{0.95} = 2{,}904$ lbs.

Amount of sand in the coarse aggregate = 2,904 − 2,758 = 146 lbs.

Stockpile amounts corrected for impurities:

From sand stockpile: 1,723 − 146 + 110 = 1,687 lbs. S.S.D.
From coarse aggregate stockpile: 2,758 − 110 + 146 = 2,794 lbs. S.S.D.

Corrections for moisture conditions:

Weight of wet sand needed:
1,687 + (0.03)1,687 = 1687 + 50.6 = 1,738 lbs.
Weight of dry coarse aggregate needed:
2794 − (0.02)2794 = 2794 − 55.9 = 2,738 lbs.

Mixing water needed

$$= 40.3 - \frac{50.6}{8.33} + \frac{55.9}{8.33} = 40.3 - 6.07 + 6.72 = 41.0 \text{ gal.}$$

Sample Surveying Field Problem—Measurement of a Distance by Pacing and Taping

Standardize the tape for 10-lb. pull and 20-lb. pull. Before starting the chain, test your pull with spring balance, and try to maintain pull within the limits of 8 to 12 lbs. (or 18 to 22 lbs.). Also pace the assigned distance before taping. Measure the distance between the two assigned points. Read the tape to the nearest 0.01 ft. Measure the distance six times, three in each direction, making certain that each party member has experience in every phase of the operation.

Sample Problem Page in Field Book—Measurement of a Distance by Pacing and Taping

Line	*Direction chaining*	*Observed length (ft.)*	*Corrected distance*	*Equipment from—*	*Date*
1A–2A.	N	214. 30	214. 34	Locker # ?	? hours
	N	214. 32	214. 36	100′ tape	Weather?
	N	214. 29	214. 33		Surveyors:
2A–1A.	S	214. 30	214. 34	Spring balance	Your Name
	S	214. 27	214. 31		Others
	S	214. 29	214. 33		

Computations

1. Mean distance: $\frac{\Sigma x}{n}=214.295=214.30$

2. Corrected mean distance:

$$\frac{214.30\times 0.02}{100}+214.30=214.34$$

Estimated distance by pacing: 215′
Length of tape with 10# pull: 100.2′
Length of tape with 20# pull: 100.3′
Measured 1A–2A from N to S
Used 10# pull
Changed positions and chained S to N
Read chain to nearest 0.01′

3. Probable error in single measurements:

$$E=\pm 0.6745\sqrt{\frac{\Sigma v^2}{N-1}}$$

V	V^2
0	0
. 02	. 0004
. 01	. 0001
0	0
. 03	. 0009
. 01	. 0001
	. 0015

$$E=\pm 0.6734\sqrt{0.0015}=\pm 0.017$$

4. Proabale error of the mean:

$$E_m=\pm\frac{E}{\sqrt{N}}=\pm\frac{0.017}{\sqrt{6}}=\pm 0.007$$

5. Accuracy:

$$Acc=\frac{E}{C.M.D.}=\frac{0.007}{214.34}=\frac{1}{30,600}$$

Put sketch here. Use straight edge, position North pointing to top of page, and tie in location of job to surroundings.

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